2

[redacted]

DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

2

AFIT/GIR/LSM/90D-7

A COMPARISON OF HUMAN-COMPUTER INTERFACES IN AIR FORCE ORGANIZATIONS

THESIS

Michael G. Morris, Captain, USAF

AFIT/GIR/LSM/90D-7

Approved for public release; distribution unlimited

The opinions and conclusions in this paper are those of the author and are not intended to represent the official position of the DOD, USAF, or any other government agency.

AFIT/GIR/LSM/90D-7

A COMPARISON OF HUMAN-COMPUTER INTERFACES IN AIR FORCE ORGANIZATIONS

THESIS

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Information Resource Management

Michael G. Morris, B.S.
Captain, USAF

December 1990

Preface

The purpose of this study was to determine the advantages and disadvantages of graphical user interfaces on personal computers used in Air Force offices. The results of this study have implications for systems analysis and design and should stimulate further study as the use of graphical user interfaces continues to grow.

In completing the research and writing for this thesis, I have had a tremendous amount of help from others. I am greatly indebted to my faculty advisor, Major L. Maurice Riggins for his advice, expertise, and support in all phases of this project. I would also like to thank my reader and program manager, Lieutenant Colonel D. J. McBride for her help on this study, as well as her expertise and leadership in all areas of the information resource management program. In addition, I would like to thank Captain Vanessa Peterson of the Advanced Tactical Fighter SPO and Mr. Orville Larison of the Wright Research and Development Center. Their support and enthusiasm for this project, particularly in its early stages, was critical to its successful completion. I would also like to thank all the members of class GIR90D who helped make the entire AFIT experience a memorable and rewarding one. In particular, I would like to thank Howard Bass, half of the best tennis doubles team AFIT has ever known, and Summer Scott, whose sense of humor and friendship always kept things in perspective. Finally, I would like to extend a special thanks to my wife, Linda, for her understanding and constant encouragement throughout the last 18 months.

Michael G. Morris

Table of Contents

List of Figures

List of Tables

AFIT/GIR/LSM/90D-7

Abstract

This ~~study~~ investigated differences in organizational efficiency and effectiveness for users of graphical user interfaces and text-based interfaces on personal computers in Air Force offices. Areas of interest included amount of time required to learn the basic system, amount of time required to learn new applications, users' ratings of user-friendliness, users' perceptions of the extent that their system helps them perform in their job, the number of software packages used on the job by users of each system, user satisfaction, responsible authorities' ratings of quality of output, and the relationship between user job experience level and interface used on the job. A literature review revealed no similar studies within the Department of Defense to date. Two populations across two organizations were identified for survey administration—users of graphical user interfaces and users of text-based interfaces. A total of 700 surveys were sent out with 454 returned for a response rate of 64.9%. The results of the study indicated that for the organizations surveyed, graphical user interfaces offer significant advantages in each of the areas investigated. Finally, the results of the study revealed that less experienced users tend to use graphical interfaces over text-based interfaces. In addition, military members used graphics-based systems in greater numbers while civilian users were more likely to use text-based systems.

A COMPARISON OF HUMAN-COMPUTER INTERFACES IN AIR FORCE ORGANIZATIONS

I. Introduction

This chapter contains a general background on human-computer interfaces and their use in Air Force organizations. The chapter provides information on the increasing popularity of graphical user interfaces and their impact on measures of job efficiency and effectiveness. The specific purpose of the research is stated, and the specific research questions are listed. Also included are limitations to the interface comparison.

Background

In Management Information Systems: *Conceptual Foundations, Structure, and Development*, Gordon B. Davis comments on the role of the interface in any management information system (MIS). He states that the emphasis in information systems has shifted away from machine efficiency to human effectiveness. His explanation for this is economic—hardware costs have declined relative to labor costs (6:333). Therefore, Davis asserts that it is incumbent upon management to maximize user productivity. Davis contends that if the user controls the interaction, he is likely to increase his level of performance. Normally this increased performance manifests itself through lower turnover and increased job satisfaction. Davis concludes that well-designed interfaces lead to impressive

performance, and therefore, should be of primary concern to managers and system designers (6:533).

As might be predicted from the ideas expressed by Davis (6), as well as those of Schneiderman (25, 26), Carey (5), and Norman (23), graphical user interfaces are increasing in popularity. Virtually all major microcomputer operating systems have implemented, or are developing, some form of graphical user interface. The growing acceptance of the Macintosh computer in the business community, as well as IBM's development of their Presentation Manager interface suggests that graphics-based systems are likely to remain a focus for systems designers well into the next decade.

Research on the effect graphical user interfaces have on job performance is contradictory. Ives, Olson, and Baroudi have correlated successful information systems implementation with user satisfaction with that system (18:785-787). Their results have challenged information managers to successfully meet the needs of computer users within the organization. To that end, Diagnostic Research, an independent research corporation, has shown that a system utilizing a graphical user interface has higher ratings from both managers and users on user-friendliness. In addition, the graphics-based system is easier to learn and creates greater feelings of confidence on the part of users of that system than users of a major character-based system (19:10). Gittins has reported that graphical systems which use icons can increase computing accuracy because icons reduce user reliance on memory for valid command sets (9:526). These studies suggest that the use of graphical interface systems has potential for increasing user satisfaction, reducing training time, and improving accuracy.

However, other studies have contradicted the notion that the user interface has an important impact on job efficiency and effectiveness. In 1985, Whiteside compared user performance on command, menu, and iconic interfaces. His results suggested that iconic interfaces do not enhance performance and that command-driven systems provide just as much accuracy as other types of systems. Additionally, Whiteside found no evidence of user preference for any of the three alternatives studied (27:190). Other academicians have criticized the graphical systems' reliance on the real world to simulate objects. This group of authors, including Grudin and Johnson, feel that simulating real world objects hinders technological progress and fails to fully address the advantages offered by automation (10:1166, 16:22). These results cast doubt about the advantages offered by graphical interface systems and suggest a need for further research in the area to better determine the role the human-computer interface plays in improving user performance.

Most of the microcomputers in use in the Air Force today use the MS-DOS operating system—a character-based, command-driven system. However, no studies have been conducted within the Air Force to compare the standard MS-DOS operating systems to alternate computer systems using graphical interfaces. By comparing the two systems, one can determine if any differences exist between character based and graphics-based systems, and if differences do exist, what the nature of these differences are, and what implications these results have for Air Force information managers.

Problem Statement

As a result of the debate about the effectiveness of graphics in computer operating systems and the growing popularity of such systems in the civilian community, the researcher determined that there was a need for further research into the effect graphical user interfaces have in an Air Force environment. The following research question best identifies the management issue described above:

What are the advantages and disadvantages of graphical, mouse-driven user interfaces as compared to character-based, command-driven user interfaces, and what is each system's impact on measures of job efficiency and job effectiveness within the Air Force?

Investigative Questions

To best answer the research question, the following investigative questions must be answered:

1. How does each type of interface compare in the amount of time required to learn the basic system?

2. How does each type of interface compare in the amount of time users report is typically required to learn a new application program?

3. How does each type of interface compare in users' ratings of user-friendliness?

4. How does each type of interface affect users' perceptions of the extent that their computer system helps them perform in their job?

5. How does each type of interface affect the number of software packages users of that system use on the job?

6. How does each type of interface affect user satisfaction with their computer system?

7. How does each type of system compare in responsible authorities' ratings of quality of output?

8. What is the nature of the relationship between users' job experience level and type of interface used on the job?

Limitations

This study compared users of the Apple Macintosh and the Zenith Z-248 computer systems. The Macintosh was chosen because it is the oldest and most widely used of all graphical user interface systems within the Air Force. Likewise, the Zenith Z-248 is the standard character-based system in use within the Air Force today.

In addition, it is possible to examine organizations with similar missions that use both MS-DOS systems and Macintoshes. This is not possible with other graphical interface systems at the present time. For this reason, the researcher chose to limit his study to organizations within the Aeronautical Systems Division, Air Force Systems Command located at Wright-Patterson Air Force Base, Ohio. By focusing on similar organizations within the same command, the researcher was able to account for potential organizational differences in making inferences based on the results of the research.

Finally, to assure that computer users responding to the survey were knowledgeable, the researcher only considered responses from computer users who reported that they use their computer at least three hours per week, have used the particular operating system for three months or more, and are familiar with more than one software application.

II. Literature Review

This chapter provides a review of significant articles and research contributions in the field. Early models for interface design, cognitive issues, the use of icons in graphics-based systems, comparative studies, system development, input control devices, display options, training issues, and special applications for graphical interface design are discussed.

Early Models

In 1980, Card, Moran and Newell examined the design and evaluation of present-day interactive computer systems. The authors recognized that users differ in many significant ways. Some of these differences included task knowledge, system knowledge, motor skills, technical ability, and experience. Under experience, the authors listed three categories of users: novice, casual, and expert. The authors also recognized a performance dimension, including separate measures of time, errors, learning, functionality, recall, concentration, fatigue, and acceptability (4:396-397).

Given these multiple dimensions, Card, Moran, and Newell focused on the amount of time it takes expert users to perform routine tasks. From this research, the authors developed their "Keystroke-Level Model," a mathematical model designed to allow systems designers to predict the time it will take a user to complete a task using the given system (4:409). Card, Moran, and Newell recognized limitations to their model in that it only considered expert users, routine tasks, and error-free performance. In their conclusion, the authors addressed these limitations in calling for more research considering other types of users, tasks, and evaluative measures

(4:409). Some of today's most popular graphical systems have incorporated these early concerns into their design, and their impact on all types of users is the basis for the research in this thesis.

In 1981, Moran built on this early research by stating that there are two ways to improve user performance. The first option was to alter the user interface, thus changing the task structure. The second option was to teach the user more efficient methods, thus increasing his knowledge (8:3). However, Moran concluded on a somewhat discouraging note for advocates of graphics-based interfaces by stating "there is a surprising number of studies that show only small differences among user interfaces for expert users" (20:9). He summarized "these results signal a general caution that many interface features have less effect on behavior than enthusiastic designers imagine" (20:9).

Cognitive Issues

Carey was among the first to comment on the correlation of interface to training costs and job satisfaction. Carey hypothesized that managers' avoidance of long training times indicates that systems designers have not been able to offer reinforcement to the user (following minimal learning) to further explore systems on his own. Carey also stated that managers are unsuccessful when they try to force unwelcome systems on their staffs. He linked stress and job dissatisfaction with inadequate systems (5:15). Carey concluded that in designing user-friendly systems (user-friendly defined as friendly to the user's mode of working), design teams should incorporate the following roles: applied cognitive psychologist, linguist, educator, cartographer, and consumer marketing consultant (5:19). Carey recognized

that like the parent field of MIS, interface design is multi-disciplinary in nature, and must consider and apply concepts from many different fields to be successful.

Ives examined the role of icons in the design of computer interfaces. Ives' research indicated a "very low entry cost" for users of graphical systems which represent familiar objects such as file folders, in/out baskets, etc. (14:36). Ives stated that because graphical systems use no unique nomenclature and no procedural language, no extensive training program is required (14:37). Ives also focused on the relationship of icons to memory limitations and reported that the use of graphics does not interfere with verbal tasks. Ives referenced research by Shepard indicating that memory for pictures is more proficient than memory for words (14:37). Although Ives did not state it directly, he implied that the use of a well-developed, icon-driven interface may be a method for increasing productivity and user-friendliness (14:36-37).

Ives' report was further amplified in conclusions reached by Norman in 1983. In his research, Norman analyzed what he termed "slips." The author defined a <u>slip</u> as a situation where the user's intention was proper, but results did not conform to that user's intention (22:254). Norman remarked that the user has a mental image of the system (a graphical representation) and how that system works. He believed that designers must be cognizant of the user's image in system design (22:257).

More specifically, Norman argued that designers should incorporate four factors into all systems. First, the system should provide feedback to the user by allowing the state of the system to be clearly available at all times. Second, there should be a similarity of response sequences. Norman felt

that different classes of actions should have separate command sequences. Third, actions should be reversible when possible; and, when not reversible, actions should be difficult to accomplish, thus preventing slips. Finally, Norman argued that the system should incorporate a consistent structure and design of command (22:257). Norman recommended that designers make use of psychological mechanisms, recognizing the importance of the way people process information. Norman believed that interface design should be based on mental models of the user and that designers should analyze the types of errors people make, and design the interface around these types of errors (22:257).

Schneiderman was the first to use the phrase "direct manipulation" to describe users' interaction with objects represented on a computer display terminal. The author found that physical, spatial or visual representations are easier to retain and manipulate—as Ives also reported. However, Schneiderman cautioned developers because he found that graphic icons which present a cluttered appearance lose their usefulness. He also warned designers that icons should have a clear meaning, and should not occupy an excessive amount of screen space (24:64). Schneiderman concluded that the use of direct manipulation, especially when implemented through graphics, offers exciting possibilities for reducing learning time, speeding performance, and increasing satisfaction (24:68).

In related research, Schneiderman stated that using psychologically-oriented experimentation is the best approach to discovering the critical aspects to interface design and provides better evidence than unsupported arguments over "user-friendliness." He felt that scientific measurement of learning time, performance speed, error rates, user satisfaction, and memory

limitations provide invaluable information for making design decisions and choosing between competing products (25:3). Schneiderman made the observation that systems employing "direct manipulation" create excitement and enthusiasm from users and lead to positive feelings of system mastery, competence in task performance, ease in learning the original system and in learning new features, confidence in the ability to retain system mastery over time, eagerness to show off the system to novices, and the desire to explore the more powerful aspects of the system (25:13-14). Schneiderman argued that systems employing "direct manipulation" allow novices to learn the basic system quickly, allow experts to work rapidly and easily implement new features, and reduce the anxiety of users because the system is understandable and actions are easily reversible (25:20).

Herot contended that ease of use is directly related to the way in which information is presented to the user (12:83). Herot was a proponent of Schneiderman's "direct manipulation," but used the term "spatial data management," to describe they way in which users can easily organize, locate, and handle a variety of information (12:84). In "spatial data management," Herot asserted that graphic representations are the most useful way to present information (12:86).

In 1985, Bennett commented on the notion of a mental model, as first discussed by Card, Moran, and Newell, in computer systems design (2:4). Bennett showed that users who interact with graphic displays form different conceptual and mental models of the system (2:5). As Davis suggested, Bennett felt that making computer systems more efficient is not enough—consideration must also be given to user limitations. Bennett stated that designers must look at cognitive variables to improve

effectiveness (2:12). Bennett remarked that the use of graphics is important to the user in forming the mental model and that graphics-based systems seem "incredibly easy to use" (2:12). In his research, the author illustrated that relatively small changes in graphic displays can have a large impact on user performance (2:13).

Hollan stressed that graphical interfaces have important cognitive properties. First, they provide a physical representational system which allows users to better understand abstract relationships and make use of the brain's powerful pattern-matching ability. Second, graphics-based systems make the depiction of models possible that are similar to the mental models or simulations people use to reason about the world. Third, graphical interfaces better depict physical state information or causal connections and allow the user to see changes in the state of the system. Finally, graphical systems provide the potential of "directly manipulable representations of systems" (13:7). Hollan stated that "interface design is currently much more of an art than a science" (13:25). Hollan maintained that we currently do not have any workable theories of interface design and therefore do not understand what contributes to the effectiveness of most successful interfaces (13:25). Hollan contended that the graphic interface creates a dynamic world in which users can interact with representations as if they were real world objects which aids the user in working with the system (13:25).

The Use of Icons in Graphics-Based Systems

More recent research has focused on the use of icons in graphics-based interfaces. Rogers commented on this trend by examining the

representation of "low imagery" (or abstract) verbs through graphics. She found that drawings of both concrete and abstract verbs were meaningful to all types of users. As one might expect, Rogers found that drawings for the "high imagery" verbs were more representative of a particular action than were "low imagery" verbs. Users were also able to match specific commands with icon sets; though again, those icons depicting concrete objects had the most matches. Therefore, Rogers stated that, for some commands, the pictorial form of the icon is critical (23:43-44). The author concluded that there is potential for using icons to represent commands without prior learning. Rogers then suggested further research on evaluating the advantages of icons versus existing command sets (23:44). Her suggestion is one of the primary objectives of this thesis.

Similarly, Gittins found that icon-based interfaces "provide more usable dialog [than command-driven interfaces] because of their capacity to carry much greater descriptive information" (9:519). He criticized undue emphasis on the original "office metaphor" stating that such emphasis shows a "lack of originality and absence of systematic design" (9:521). Gittins then listed a number of advantages and disadvantages of icon-driven interfaces.

Among the advantages, Gittins stated that the user can infer function from pictographic symbols. Second, he reported that icons aid in reducing errors. Users are more accurate because they are able to choose from a given set of choices and are not reliant on their memory of valid commands. Third, Gittins stated that icons can illustrate commonality between similar concepts. Fourth, as Schneiderman first described, Gittins reported that icons facilitate direct manipulation of items on-screen. Last, Gittins stated

that designers can get more information to the user in a smaller space—in the cognitive sense as well as the literal sense (9:526-527).

Among the disadvantages, Gittins found that it was difficult to represent some functions with icons, though it did help to add words to those particular icons. This finding supported Rogers' study, though Rogers still found potential for using icons to represent abstract concepts (23:43-44). Gittins also found that intricate designs and color can complicate (rather than simplify) user dialog. Finally, the author stated that it is extremely difficult to establish any measure of "usability" for icon-based systems (9:527-529).

Johnson complemented Gittins' with his argument that computers should not try to approximate the actual office. Johnson felt that the use of the "desktop metaphor" in graphical, direct manipulation interfaces was flawed (16:21). Johnson argued that the goal of making a system easy to learn through the use of familiar objects is lost when designers try to simulate the desktop in too literal terms. Johnson believed that most systems do not recognize that manipulating objects on-screen is often more difficult than actually manipulating those objects in the physical world. He felt that systems using the "desktop metaphor" create unnecessary development effort and poor system performance. Similarly, Johnson stated that these systems often limit electronic functionality to that of the physical object that is represented, and do not address a "better" way of doing things (16:22). Finally, Johnson commented that though this type of interface is familiar, it is not necessarily optimal. He stated that there are no rules for how detailed the metaphor should be (16:23). Johnson concluded by stating that deviations from the "desktop metaphor" are often necessary. He stated

that unless designers understand when and why to simulate the reai office, they are likely to end up with a sophisticated product that is difficult to use (16:23).

Guastello, Traut, and Korienek completed the most recent research on the use of icons and published their results in July 1989. The authors listed three important considerations for systems designers. First, icons which mix pictures and words are more meaningful than verbal or pictorial icons only. Second, the authors found that the validity of using "mixed modality" icons (combining verbal and pictorial representations) is true across diverse content areas, including engineering, data processing, and financial arenas. Finally, Guastello, Traut, and Korienek reported that it is possible to design new icons that are more meaningful than current industry standards (11:119). The authors premise was that interface design must be based on data obtained from the user population (11:99). The authors concluded that the survey method is the most appropriate way to obtain this data and apply it to the study of human-computer interaction (11:119).

Comparative Studies

John Whiteside examined the performance and reactions of 76 users with seven different commercial interfaces representing command, menu and iconic interfaces. In his tests, the basis for comparison among the interfaces was user performance and preference on a specially-designed, standardized task that stressed simple filing operations (27:185). Specifically, Whiteside attempted to answer 3 questions:

1. Are there large user performance differences between interfaces?
2. What style of interface is best for what level of user?

3. Can performance differences be attributed to interface style? (27:185)

In evaluating these questions Whiteside made the point that each type of interface was tested as a whole system. That is, no attempt was made to isolate the mode of presentation, the terminal used, or the keyboard used. The author claimed that the entire system represents a design team's best solution to optimizing many variables; therefore, it is more appropriate to test the whole system (27:185). Whiteside presented the user with minimal information on each system ahead of time, but the user did receive the documentation for each system. Users were then required to complete basic file manipulation procedures on text files including displaying, merging, and sending to other users. Results were recorded using performance measures, videotapes, interviews, and questionnaires. The researcher controlled the task performed and the users' computer background (27:186-187).

The results of Whiteside's study were surprising. He found that new users performed better on command and menu systems than on iconic systems. He also found that one icon system was much preferred over a second icon system. There were also feedback problems noted on all systems tested. On the command system, users became frustrated due to the inconsistency of function key operations across all applications. Finally, Whiteside noted difficulty with using the mouse on icon systems due to that input device's perceived lack of reliability (from the user's perspective) (27:187-189).

Overall, Whiteside noted large differences in the performance of what the author called new, transfer, and system users. There were also large

differences between systems; however, these differences were not dependent on the user's experience level (new, transfer, or system). After also considering user's qualitative ratings for each system, in addition to the performance measures outlined above, Whiteside concluded that the menuing system was the worst—especially for new users. The author stated that this was surprising because menu systems are typically designed to ease computing for new users. In addition, no icon system allowed the beginner to produce useful work within a half hour unassisted. Whiteside also discovered that there was no evidence that making systems easy for beginners makes those same systems difficult for experts. In fact, Whiteside's results suggest that making systems easy to use for beginners also improves ease of use for experts. This result is also counterintuitive to conventional arguments on interface design (27:189-190). In summing up his results, Whiteside stated that interface style did not emerge as an important predictor of performance or preference on different systems. Second, new interface styles do not, by themselves, solve old human factors problems. Some problems were common across all three types of interfaces. Finally, the author concluded that rather than the type of interface, the care with which it is designed and built is the critical factor in the success of that system and that this comes with product maturity (27:190). Whiteside's study is important because it refutes many traditional arguments for specific types of interfaces with empirical evidence to the contrary. His results indicate a need for further study in this area to determine what impact, if any, the interface has on different types of users.

In contrast to Whiteside's study, Diagnostic Research, Inc. conducted two studies in 1988 among Macintosh users and MS-DOS users and found

that users rated the Macintosh system higher in virtually all areas that were measured in the study. One study was conducted among MIS managers familiar with both Macintosh and MS-DOS systems. The second study consisted of Fortune 1000 professionals from other departments who regularly used either Macintosh or MS-DOS personal computers in their work. Issues examined were user productivity, ease of use, and training time (19:1).

Overall, Diagnostic Research's results indicated the Macintosh has advantages over MS-DOS systems. In the productivity category, the Macintosh was judged easier for learning the system and for learning new applications (19:3). In training time and costs, users reported learning the Macintosh twice as fast as MS-DOS, cutting training costs in half. MIS managers reported a mean training cost of approximately $300 for Macintosh users compared with $750 for MS-DOS users. Approximately 20 hours of training time was required per MS-DOS user versus 9 hours for Macintosh users (19:5-6). In support time, managers reported that MS-DOS systems required approximately 31 hours per month per computer as compared with only 15 hours for Macintosh systems (19:7). The Macintosh also received higher ratings on the quality of business graphics and the quality of printed output (19:8). Macintosh users also reported that they were familiar with 57 percent more software applications than MS-DOS users (19:9). Finally, users of the Macintosh rated their system higher than MS-DOS users for being enjoyable to use and giving them confidence in using their computer. MIS managers also gave the Macintosh higher ratings for end user satisfaction (19:10).

These results are not what one would expect after examining the results of Whiteside's study. The results of Diagnostic Research's study are the most definitive evidence to date endorsing the use of a particular graphical user interface. However, when compared with similar research in the field, there is still disagreement on exactly what impact the interface has on measures of user productivity.

System Development

One of the major reasons that graphical user interfaces have been relatively slow in gaining acceptance is the difficulties they pose for developers. Though often viewed as easy to use from the user's perspective, from the developer's perspective graphical user interfaces are usually more difficult to design. Because of their design difficulty, graphical user interfaces are more costly to develop, thus keeping many major developers out of the graphical market.

Wixon and Whiteside emphasized that development of a system which is easy to use does not occur from simply good intentions or a lot of money for development (28:144). Wixon and Whiteside developed a project known as the User-Derived Interface (UDI) which attempted to build a system which allows novices to perform simple tasks in one hour without consulting a manual, on-line help, or a tutorial. In developing the UDI, the authors found that "usability" was difficult to define. Wixon and Whiteside listed two alternative definitions of "usability." The first definition was a system which supports high levels of productivity for those who use that system continuously after much training. The second definition was a system which allows the user to complete productive work within the first

half hour without any training (28:145). In summing up their work on the UDI project, the authors commented on the importance of setting levels of usability to be achieved for "success" in advance. Secondly, Wixon and Whiteside advocated taking a prototyping approach to developing an interface for usability. The authors felt that a program of iterative testing with very short development and test cycles best meets the needs of users (28:145-146). Finally, and most importantly, Wixon and Whiteside believed that building usability into an interface design requires a systematic, engineering process (28:147).

Keith A. Butler also described the importance that the design stage plays in developing effective user interfaces. Butler defined "learnability" as a key attribute because of its importance to the user's perception of system quality (3:85). The author described a system for designing usable systems based on empirical definitions of desirable system performance. Specifically, Butler advocated specifying user performance objectives as part of the product definition stage, applying human factors principles and methods during the design and implementation stage of product development, and performing testing of user performance to evaluate whether the product meets user performance objectives specified in the product definition stage (3:85). Butler stated that there are three main dimensions of performance that comprise usability: learnability, throughput, and user attitude. He also stated that one can define "user-friendliness" by quantifying the probability of task completion (3:86). To test his theory, Butler gave subjects a problem and left them with a users guide to software developed using his three development principles. Butler's main contention was that in interactive systems, just meeting

performance criteria is not enough—the developer must also consider user performance criteria to increase productivity (3:88). After testing, Butler found that his systematic approach does offer impressive performance. In his test, subjects completed problems in an average of 123.8 minutes compared with 180 minutes which was defined as the learnability objective (3:88). Butler's results lend further credence to the importance of defining usability objectives in advance of the design effort and suggests that systems which skip this design stage may suffer unforeseen problems with user acceptance or learning.

In evaluating the effectiveness of a particular design effort, Michelle A. Lund recommended a prototyping approach for design teams. Lund suggested that when designing an interface for graphics applications, as portions of the design phase are completed, give potential users a task to complete then observe and videotape the results. Her thesis was that although developers can (and should) test their efforts, there is no substitute for human factors testing with real users. By testing in this manner, developers can discover surprises about likes and dislikes. The prototyping approach then allows designers to make changes while still in the development stage before releasing the product to the field (18:107). Lund stated that interface testing should include several elements. First, the testing should determine how well a system anticipates a user's train of thought. Second, when the user gets lost, testing should reveal what led the user in the wrong direction. Third, testing should discover problems the first time a user encounters them—before the user becomes accustomed to it. Fourth, the test should document how the user reacts to specific design features (such as help screens, etc.). Finally, the testing should indicate

what concepts need to be stressed in training and in the documentation for the system (18:109). Lund felt that the best way to test users is to give them a problem, having them vocalize all thoughts as they try to solve this problem with the system. The evaluator then videotapes the entire session to capture the user's reactions to the system in a given situation. Lund stated that she finds this evaluation method highly effective because it successfully identifies problems in the user interface, and it allows designers to verify that design changes have improved the system under development upon re-test (18:112-113).

Input Control Devices for Graphics-Based Systems

Since virtually all graphical interfaces are mouse-driven, research into the features of various input devices is an important consideration. Embley and Nagy examined different behavioral aspects of text editors. One category that the authors examined as part of their study was input devices. Using the aforementioned Card model, Embley and Nagy reported that "the mouse is a uniformly superior cursor control device with respect to both speed and error rate" (8:62). However, for some tasks, the authors reccmmended that keyboard control be retained (8:62).

On the other hand, a study conducted in 1986 by Karat, McDonald, and Anderson contradicted the findings of Embley and Nagy. Compared to the touch panel and keyboard, the mouse was the least preferred input control device (17:81). Recognizing the studies of Embley and Nagy (as well as others), Karat, McDonald, and Anderson listed several limitations to their research which may have had an impact on their findings. First, the subjects used in their first set of experiments were all skilled typists.

Second, the mouse was a new device for all the subjects tested and was therefore less familiar than either touch panels or keyboards (17:74). In their conclusion, the authors stated that despite their findings reporting a preference for touch panels as an input control device, the mouse offers the advantage of allowing programmed functions to be built into the mouse buttons—an advantage not possible with touch panels (17:88).

Display Options

Grudin contradicted the more popular argument for interface consistency offered by Schneiderman and others (10:1164). Whereas Schneiderman stated that maintaining consistent properties leads to better interface design, Grudin argued that interface consistency is unworkable. While interface consistency can contribute to ease of learning, Grudin argued that ease of learning often conflicts with ease of use—an argument which Whiteside rejected in his research (27:189). Particularly for skilled users, Grudin believed that interface consistency works against good design (10:1166). The author believed that as task knowledge increases, consistency becomes less important and maintaining consistency across a wide range of applications and types of users, like the Macintosh, leads to increasing performance costs. Like Johnson, Grudin felt that adhering to real world objects in designing interfaces does not make the best use of available technology (10:1166). Grudin's solution in designing an interface was to fully know and understand the intended users and tasks better than anyone else (10:1172). Grudin's research is significant because it is one of the only published works in the field which argues against maintaining

interface consistency and suggests that the look and feel of the interface may not be as important as once thought.

Daniel J. Dwyer examined the effect that screen size has on graphical displays and job performance. In his experiments, Dwyer tested screens with 5" x 5", 9" x 9", and 12" x 12" displays. After conducting his tests, the researcher concluded that screen size has an effect on response accuracy only when discriminability between test points is low (7:11). Dwyer found that when a graphic display is composed of many similar densely-packed points, these points tend to compete for a person's attention on smaller screen sizes. However, when the ability to discriminate between points is relatively easy, accuracy fluctuates only slightly (7:11). Finally, Dwyer found no impact of screen resolution on response accuracy (7:12). There is currently no literature indicating any link between resolution and screen size. These findings suggest that arguments against some graphics-based systems which use small screen sizes, like the Macintosh, may not be valid. On the other hand, many graphics-based systems counter the argument against small screen size with their argument for superior resolution. Again, Dwyer's results refute this argument and suggest that screen resolution may not have an impact on productivity.

Training and Learning Issues

Ives, Olson, and Baroudi stated that most MIS failures come from a lack of user acceptance of that system. They also found that a system which meets the needs of its users will reinforce satisfaction with that system. Conversely, a system which fails to meet the needs of its users will reinforce dissatisfaction with that system (15:785-787). Ives, Olson, and

Baroudi's results have challenged organizations to help increase user satisfaction. One of the ways which organizations have attempted to do this is through structured training programs designed to increase familiarity with the system and promote user acceptance of that system.

Following Ives, Olson, and Baroudi's findings, Nelson and Cheney conducted a field study of 100 middle and upper level managers in 20 companies. In the authors' literature review, they found a lack of consensus on whether training was the critical factor in getting managers to use information systems technology (21:556). In their survey, Nelson and Cheney found that respondents reported, almost exclusively, that they felt training was important to the successful integration of information systems products. However, the researchers also found that only two percent of information systems resources were spent on training end users (21:556). From their results in the 20 organizations researched, Nelson and Cheney found that there is a positive relationship between the computer training that a user receives and the user's ability to use the computer. In addition, the authors found that there is a positive relationship between the user's ability and their utilization and satisfaction with information systems technology (21:554-555). From these results, Nelson and Cheney concluded that information systems-related education and training leads to acceptance and usage of information systems technologies throughout the organization (21:547).

John C. Thomas of the IBM Research Center also believed that interface design is critical to the success of today's computer user. Thomas emphasized that early computer users were dedicated, technical specialists. As hardware costs have fallen, the installed user base has broadened to

include all types of users. These two factors have led to a much greater importance on the ease with which computer systems can be learned and used. Observations at the IBM Research Center indicate that it is unlikely that new users will sit down and read a 100 page manual. Thomas found that users are more likely to skip around and try out different functions (26:31). Thomas stated that individual ability and attitude toward the computer system tremendously affect productivity (26:32). For office personnel, Thomas contended that ease of use, ease of learning, enjoyability, and the perceived effect on productivity will have a great impact on computer sales to the population in question (26:34). In addition, the author postulated that the more difficult a system is to use, the higher marketing costs will be and the higher service costs for that system will be (26:35). Thomas summarized by stating that only by designing and organizing for human factors considerations can these limitations be overcome (26:45).

Special Applications for Graphical Interface Design

Unlike Grudin, Adcock addressed a need for a single, unified user interface which allows database users to accomplish all activities within a single environment. Adcock believed that a graphical interface presents the greatest potential (1:12). Among the advantages of this type of system, Adcock stated that the increased dimensions offered by pictures, the ease of learning and transferring knowledge through pictures, and the increased ability to represent the real world are not found in any other system available (1:12). Adcock outlined a database system with a graphical interface to best fulfill the properties of descriptiveness, power, and ease of use and learning. Adcock remarked that the graphical interface is

necessary in today's environment due to the growing diversity of the user base (1:46). His database system was designed to facilitate ease of learning through use of a consistent, graphics-based operating environment (1:46).

Summary

Based on the review of the literature, there appears to be agreement that the diffusion of computer systems to a wider base of users has created a need for systems that are easy to learn and easy to use. Likewise, research indicates that organizations which place emphasis on training users are more likely to successfully implement information systems technologies. However, the effect that graphical user interfaces have on this process is not clear. Many authors, including Schneiderman, Norman, Hollan, and others have stated that graphical systems are effective at facilitating end-user computing. However, another somewhat smaller group of authors, including Grudin and Whiteside, have argued that the interface's role in creating workable, easy-to-use systems is not as significant as one might expect. There is evidence to suggest that the type of user and the type of task involved may determine the appropriateness of a particular interface for a given environment. To date, no research has been conducted in Air Force offices to determine if graphical user interfaces have any impact on job efficiency and effectiveness.

III. Methodology

This chapter describes the methodology that was used to accomplish the research objectives and to answer the research and investigative questions listed in Chapter 1 of this study. Selection of the methodology, the population from which the data was collected, the survey instruments which were used to collect data, and the statistical tests which were used to analyze the data are described.

Selection of Methodology

The survey method was chosen to solve the research problem. There were important advantages to the survey method used in this research. First, it allowed the researcher to gather results from a large sample population. The number of individuals sampled in this study would not have been feasible with any other method. Because the survey methodology allowed the researcher to gather data from a large number of individuals, the researcher felt that external validity was enhanced over other potential methodologies for this research. Finally, the use of a questionnaire with pre-defined rating scales facilitated statistical analysis of results allowing the researcher to easily compare separate populations.

However, one distinct disadvantage was also considered before choosing the survey methodology. Because no survey instruments were available, a written questionnaire was constructed to answer the investigative questions listed in Chapter 1. To help improve internal validity, the questionnaire was submitted to a panel of experts on computer systems and survey instruments to insure that undesirable psychometric

qualities were eliminated. By taking these precautions, the researcher felt confident that the benefits afforded by quantitative analysis of a large user population outweighed any potential disadvantages to the survey methodology.

Population

There were two populations of interest for this study. The first population consisted of users of MS-DOS (primarily Zenith Z-248) computer systems within the Advanced Tactical Fighter Special Programs Office and Wright Research and Development Center located at Wright-Patterson AFB, OH. The second population consisted of users of the Apple Macintosh computer system within the same organizations. Users in each population were limited to computer users who used their computer at least three hours per week, had used the particular operating system for three months or more, and were familiar with more than one software application. These qualifications insured that all individuals sampled had an adequate level of knowledge about the system to effectively evaluate that system's contribution to each of the performance measures.

A non-probability judgement sample was chosen for the research. That is, only individuals meeting the criteria specified above were surveyed. The researcher felt that this sampling plan was the best alternative and allowed him to best measure the variables being researched in this study. The purposive sample allowed the researcher to isolate two distinct populations and eliminate intervening variables such as organizational environment and computer experience (or lack thereof) on a particular system being studied. However, care must be taken in over-generalizing

the results of this research to organizations with dissimilar structure or demographics.

Survey Instrument

The investigative questions used in this study were as follows:

1. How does each type of interface compare in the amount of time required to learn the basic system?

2. How does each type of interface compare in the amount of time users report is typically required to learn a new application program?

3. How does each type of interface compare in users' ratings of user-friendliness?

4. How does each type of interface affect users' perceptions of the extent that their computer system helps them perform in their job?

5. How does each type of interface affect the number of software packages users of that system use on the job?

6. How does each type of interface affect user satisfaction with their computer system?

7. How does each type of system compare in responsible authorities' ratings of quality of output?

8. What is the nature of the relationship between users' job experience level and type of interface used on the job?

A survey questionnaire (see Appendix) was constructed to gather data and appropriate measurements for the questions outlined above. For the purpose of this study, all responses were considered to be at least interval-level data.

To improve internal validity of the instrument, the questionnaire was submitted to a panel of experts in both information systems and survey design. Members of this panel included Captain Carl L. Davis, Assistant Professor of Research Methods and Technical Communication; Dr. Charles R. Fenno, Associate Professor of Research Methods and Technical Communication; Lieutenant Colonel Dorothy J. McBride, Program Manager for the Information Resource Management graduate program; Lieutenant Colonel Richard E. Peschke, Assistant Professor of Logistics Management; and Major L. Maurice Riggins, Instructor in Logistics Management. Panel expertise was consolidated and both content and structural changes to the questionnaire were incorporated before final submission of the survey instrument to the Commander, Aeronautical Systems Division for approval.

The survey questionnaire was divided into seven sections. Section 1 consisted of demographic questions, including questions designed to screen individuals answering the questionnaire based on the criteria listed above for the judgement sample used in this study. In addition, the information gathered in Section 1 was used in the contingency table analysis used to answer Investigative Question 8.

Section 2 was designed to answer Investigative Question 1. It was based in principle on research first conducted by Carey, Ives, and Schneiderman (5:14, 14:15, 25:57). This section first asked respondents whether they knew how to accomplish a set of basic file operations common to each type of interface. Then, users were asked how much time it took them to learn to perform all of the basic file operations listed in the questionnaire. Using the file operations listed in the questionnaire as a benchmark, the researcher was then able to draw conclusions about how

much time was required to learn the basic system for each type of interface.

Section 3 of the questionnaire was constructed to answer Investigative Questions 2 and 5. Diagnostic Research's analysis of Macintosh and MS-DOS computer users formed the basis for questionnaire design for this portion of the study (19:1). The questionnaire asked users whether they used their computer for specific types of applications. Based on the organizations surveyed, the researcher asked users about word processing, spreadsheet, database, graphics/presentation, and engineering applications. If users responded that they did use their computer for a specific type of application, they were then asked how much time it took them to learn to use that type of application on their computer. The researcher was then able to compare how much time users reported was required to learn new applications for each type of interface. Finally, the researcher asked respondents how many application programs they felt proficient on. The results from this item as well as the responses to the application-specific questions yielded data used to answer Investigative Question 5.

Section 4 was designed to answer Investigative Question 3. This section was designed based on the ideas presented by Gittins, Herot, and Johnson (9:519, 12:83, 16:21). Users were first presented with a seven-point Likert scale and were asked to use the scale to respond to a series of specific questions about working with the interface on their computer. Users of the MS-DOS and Macintosh systems answered different sets of questions in this section to account for the substantially different ways of working with each type of interface. However, questions were developed around the same fundamental practices used in each type of interface. Care

was taken to insure that the questions used in this section asked about equivalent operations for each interface. The results from this series of questions were used to determine whether there were differences in users' ratings of user-friendliness for each type of system.

Section 5 of the questionnaire was used to answer Investigative Questions 4 and 6. Research by Butler, Carey, Herot, Diagnostic Research, and Whiteside was used in developing this area of research (3:85, 5:14, 12:83, 19:1, 28:185). This section also presented the respondent with a seven-point Likert scale. Users were asked to use this scale to respond to a series of statements developed by the researcher. In this section, users were given statements designed to measure their satisfaction with their current computer system and its impact on their job. This portion was used to determine whether one set of computer users had a higher level of user satisfaction than another group.. In addition, this portion was used to determine whether one population of users felt that their computer helped them perform their job better than the other population of computer users.

Section 6 was used to answer Investigative Question 7. This section was developed based on the researcher's preliminary interviews with computer systems personnel in the organizations surveyed. Respondents were asked if they supervised other personnel or whether they were responsible for output generated by a computer. Users who responded affirmatively to either question were defined as responsible authorities and were then asked to respond to a series of questions about the output from their computer system using a seven-point Likert scale. The responsible authorities were asked to rate the quality of text, quality of graphics, and the overall appearance of documents produced by their computer system.

The results from these areas were used to determine if there were any differences in the two systems studied in quality of output.

Section 7 was a set of open-ended questions about what specific applications were used in each of the five areas (word processing, spreadsheet, database, graphics/presentation, and engineering) studied for Investigative Question 2. Users were asked to write in the name of the application used for each area on their computer system. The results from this section were used to gather information about what applications were actually being used to insure that similar-quality products were being used and that valid comparisons could be made about the interface's impact on ease-of-use for each type of application studied. Section 7 was developed as a separate section at the end of the questionnaire so that respondents could simply write the name of the appropriate programs on the questionnaire without having to respond to a multiple choice format on the computerized answer sheet. By placing this section at the end, separate from Section 3, the researcher felt that users would not be as likely to get confused by changing from computerized answer sheets to the actual questionnaire. This approach also simplified the data analysis process by segregating the central issues of the study in Section 3 from the peripheral control issues examined in Section 7.

The questionnaire was submitted to the Commander, Aeronautical Systems Division, for approval before sending to sampled organizations. Included in the package submitted to his office was a letter for the Chief of Staff's signature to sampled agencies indicating his support for the research. Following his approval, the researcher assembled the packages sent to each population. Packages were assembled in Air Force envelopes

and included the cover letter, questionnaire instructions, survey questionnaire, answer sheet (AFIT Form 11C) and a return Air Force envelope. The return envelope was stamped with the researcher's organizational address to facilitate prompt return of the questionnaire and improve the response rate. A total of 700 surveys were mailed to the organizations included in the sample.

Data Collection and Analysis

Four weeks were initially allowed for the return of the questionnaires. The researcher felt that this period gave respondents ample time to respond to the survey. However, due to a distribution problem at one of the sampled agencies, the suspense date was extended for one week to insure that all users had the opportunity to participate in the survey. As questionnaire answer sheets were returned, the researcher examined the responses to the demographic questions to insure that the response met the conditions established for the sample. In addition, the researcher tallied the hand-written responses on the last section of the questionnaire for those respondents meeting the qualifications. Valid answer sheets were then separated and stored for optical scanning. Answer sheets not meeting the established conditions were separated and stored for future reference. The data was analyzed using the StatView statistical software package from BrainPower, Inc. The responses consisted of nominal and interval level data.

The seven-point Likert scale responses were assumed to be at least interval level data. In addition, because a return rate of less than 100 percent was anticipated, it was assumed that the Central Limit Theorem

applied to this research. The Central Limit Theorem states that for large sample sizes, 30 or more cases, the data can be assumed to be normally distributed.

It is important to note that this thesis is designed to examine the user interface only, and should not be viewed as a recommendation for a particular computer system. For example, cost and connectivity considerations were not considered in this evaluation. While those functions are critical concerns in choosing a system, they were not addressed in this thesis as they are not directly related to the design of computer interfaces and their effect on computer users.

In interpreting the data, it is important to remember that results were obtained based on users' perceptions, rather than on actual observed preference or usage patterns. Questionnaire responses were assumed to be accurate and represent the honest opinions of those surveyed.

Statistical Tests

The primary statistical tests used to analyze the data were contingency table analysis and the t-test. Contingency table analysis was used to determine whether two variables were independent. To test the hypothesis that two variables were independent, the researcher compared expected values to observed values for each variable. This result was used to determine the probability that differences of the magnitude demonstrated would occur if each value were actually independent. Analyses which rejected the null hypothesis were supplemented by using the t-test to further examine the nature of the relationship between the two variables in question.

The t-test was used to determine the significance of the difference of means between two populations. To test the hypothesis that the population means were equal, the researcher calculated the t-statistic by dividing the difference between the sample means by the sum of the sample standard deviations. The value yielded by this result was used to determine the probability that a difference of the magnitude demonstrated would occur if the population means were actually equal. Differences were declared significant at the .05 significance level.

The results of all contingency tables and t-tests were then analyzed to determine the advantages and disadvantages offered by graphical systems as compared to character-based systems. Contingency table analyses rejecting the hypothesis of independence followed by t-test results indicating a significant difference between the means for each system were presumed to indicate an advantage for one system over its counterpart. On the other hand, if the t-test did not indicate a significant difference in the two systems, it was not listed as either an advantage or disadvantage. The results of all contingency table analyses and t-tests were then used to draw conclusions about the design of computer interfaces and their impact on human effectiveness and efficiency within Air Force organizations.

IV. Data Analysis

This chapter presents the data analysis from the survey instrument. It first outlines the demographic data for the sample population followed by the data relative to each investigative question.

As stated in the methodology portion, a total of 700 surveys were mailed out. 200 of these surveys went to the Advanced Tactical Fighter SPO, and 500 of the surveys went to the Wright Research and Development Center. These figures reflect the difference in the number of computer users for each organization. 454 of the original 700 surveys were returned for a response rate of 64.9%. From the 454 surveys returned, 77 were eliminated because they failed to meet the conditions specified for this research, leaving a total of 377 responses for analysis. The elimination rate was proportionally divided among the two organizations surveyed. The figures presented in this chapter reflect only those 377 qualified responses. Note that when percentages are used, results are rounded to the nearest tenth and therefore may not sum to exactly 100.0%.

Demographic Information

Question 1 asked respondents to identify their organization. The organizational breakdown is presented in Table 1 on the following page. There were no major differences in the demographic responses for each organization. Information presented in the following tables is aggregated across both organizations.

Question 2 asked respondents which category best described their primary job. The job categories and their associated responses are

presented in Table 2 on the following page. The large number of engineers responding is indicative of the primary mission of each of the organizations included in this study.

Table 1

Number and Percentage of Responses by Organization

Organization	Number	Percentage
Advanced Tactical Fighter SPO	126	33.4
Wright Research and Development Center	251	66.6

Table 2

Number and Percentage of Responses by Job Category

Job Category	Number	Percentage
Secretarial	30	8.0
Administrative	19	5.1
Management	89	23.7
Engineering	185	49.2
Finance/Cost	14	3.7
Computer Operations	25	6.6
Security	1	.3
Other	13	3.5

Question 3 asked respondents for their grade. The breakdown by grade is presented in Table 3 on the following page. The few number of enlisted

responses as well as the large number of senior civilian responses is again indicative of the missions performed by the organizations studied.

Table 3

Number and Percentage of Responses by Grade

Grade	Number	Percentage
E1-E3	0	0
E4-E6	7	1.9
E7-E9	3	.8
O1-O3	78	20.9
O4-O5	32	8.6
O6 or above	9	2.4
GS1-GS7	37	9.9
GS8 or above	208	55.6

Question 4 asked respondents the total length of time that they have been employed by the federal government. The length of federal service responses are listed in Table 4 on the following page. As indicated in the table, the sample used for this research had a high level of experience, with the largest group of respondents reporting over 12 years of federal service.

Question 5 asked respondents how long they have been in their present job. While those with over 4 years of experience in their present job comprised the largest group, responses were well-distributed throughout the range of responses used on the survey. The breakdown by length of time in present job is presented in Table 5 on the following page.

Table 4

Number and Percentage of Responses by Length of Federal Service

Length of Federal Government Service	Number	Percentage
Less than 1 year	17	4.6
At least 1 but less than 3 years	36	9.7
At least 3 but less than 5 years	53	14.2
At least 5 but less than 8 years	54	14.5
At least 8 but less than 12 years	66	17.7
12 years or more	147	39.4

Table 5

Number and Percentage of Responses by Length of Time in Present Job

Length of Time in Present Job	Number	Percentage
Less than 1 year	80	21.3
At least 1 but less than 2 years	79	21.0
At least 2 but less than 3 years	58	15.4
At least 3 but less than 4 years	55	14.6
4 years or more	104	27.7

Question 6 asked respondents for their highest level of education. The number and percentage responses by education level are presented in Table 6 on the following page. The relatively high education level again reflects the job and grade structure presented earlier.

Table 6

Number and Percentage of Responses by Education Level

Highest Level of Education	Number	Percentage
High school graduate	17	4.5
Some college	47	12.5
Associate's degree	9	2.4
Bachelor's degree	164	43.6
Master's degree	122	32.4
Doctoral degree	17	4.5

Question 7 asked respondents whether they used a computer on the job and was only used as a means to screen responses for Questions 8-11. Those users responding that they did not use a computer on the job were eliminated from consideration and were not included in any of the analyses used in this study.

Of those respondents indicating that they used a computer on the job in Question 7, Question 8 asked respondents what type of computer they used most often. To control the type of text-based and graphical interfaces used in this analysis, only respondents using IBM compatible or Apple Macintosh computers were included in this study. MS-DOS compatible systems made up the largest group of users; however, the number of Macintosh users was also substantial. The large number of respondents in each category allowed the researcher to conduct a thorough analysis for each of the variables studied. Breakdown of responses by type of computer used most often on the job is presented in Table 7 on the following page.

Table 7

Number and Percentage of Responses by Computer Type

Type of computer used most often	Number	Percentage
Zenith Z-248 or other IBM compatible	218	57.8
Apple Macintosh	159	42.2
Other*	0	0

* Respondents choosing "other" were disqualified under the parameters established for this study and were not considered in the data analysis.

Question 9 asked respondents how long they have used the computer specified in their response to Question 8. In order to ensure that respondents were able to conduct a fair evaluation of the interfaces examined in this study, users with less than three months' experience were eliminated and were not included in the analysis.

As shown in the table, the largest group of respondents reported over one year of experience on the computer system used on the job. 274 of the 377 total users (72.7%) were in the most experienced category. 103 of the 377 users responding, or 27.3%, reported using their system between three months and one year. The researcher felt that this large base of experienced users ensured that respondents were adequately qualified to evaluate each interface thoroughly and enhanced the validity of the study. Table 8 on the following page presents the number and percentage of responses for length of computer use.

Table 8

Number and Percentage of Responses by Length of Use for Computer Specified in Response to Question 8

Length of Use	Number	Percentage
Less than 3 months*	0	0
At least 3 months but less than 1 year	103	27.3
1 year or more	274	72.7

* Respondents choosing "less than 3 months" were disqualified under the parameters established for this study and were not considered in the data analysis.

Question 10 asked users approximately how many hours per week they use their computer on the job. As described in Chapter III, respondents who used their computer less than three hours per week were disqualified from further data analysis under the parameters established for this study. Table 9 on the following page presents the number and percentage of responses for each category.

Question 11 asked respondents how many different software packages they use on the job. As described earlier in the study, only those respondents using more than one software package on the job were considered in the data analysis under the parameters established for this research. Breakdown by numbers of software packages used is presented in Table 10 on the following page.

Table 9

Number and Percentage of Responses by Hours of Computer Use Per Week

Hours of computer use per week	Number	Percentage
Less than 3*	0	0
At least 3 but less than 5	45	12.0
At least 5 but less than 10	87	23.1
At least 10 but less than 20	145	38.6
20 or more	98	26.1

* Respondents choosing "less than 3" were disqualified under the parameters established for this study and were not considered in the data analysis.

Table 10

Number and Percentage of Responses by Number of Software Packages Used on the Job

Number of Software Packages Used	Number	Percentage
1*	0	0
2-3	100	26.5
4-6	149	39.5
Over 6	128	34.0

* Respondents answering "1" were disqualified under the parameters established for this study and were not considered in the data analysis.

Question 17 asked respondents to rate their computer skill level on a scale of 1 to 5, with 1 being the least advanced and 5 being the most advanced. The overall number and percentage of responses are reported for demographic purposes in Table 11 below.

Table 11

Number and Percentage of Responses by User Computer Skill Level

User Computer Skill Level	Number	Percentage
1	8	2.2
2	26	7.1
3	157	43.1
4	115	31.6
5	58	15.9

Investigative Question 1

The researcher used contingency table analysis to test the hypothesis that type of computer used on the job and time required to learn the basic system were independent. Contingency table analysis calculates an expected number of responses, based on the number of responses for each group, and compares that figure with the actual observed number of responses for each group. In all of the contingency tables presented in this study, users responding that they did not use that application were eliminated from the analysis. These observed and expected frequencies are presented in Table 12 below. Observed frequencies are listed first, followed by expected frequencies, indicated by parentheses.

As shown in the table, the greatest discrepancies between observed and expected frequencies exist at the extreme ends of the response scale while the middle range frequencies do not deviate markedly from the expected values.

Table 12

Observed and Expected Frequencies for Computer Type vs. Time Required to Learn the Basic System

Hours	MS-DOS users	Macintosh users	Totals
Less than 1	49 (61.14)	59 (46.86)	108
1-3	70 (70.2)	54 (53.8)	124
3-5	34 (31.14)	21 (23.86)	55
5-7	7 (13.59)	7 (10.41)	24
More than 7	27 (20.95)	10 (16.05)	37
Totals	197	151	348

Total Chi-Square - 12.173

p - .0161

The researcher was forced to combine response 6 with response 5 to meet the minimum requirement of 5 responses per block for contingency table analysis. As shown in the table, the overall p value for the Chi-Square value obtained for this analysis was .0161. This p value strongly suggests that type of computer used on the job and time required to learn the basic system are not independent.

Based on the results obtained in the contingency table analysis, the researcher conducted a one-tail t-test to determine whether the mean response for users of text-based interfaces was higher than that for users of graphical user interfaces (a higher mean indicating that time required to learn the basic system was higher). Again, for all t-tests used in this study, users responding that they did not use that particular application were eliminated from the analysis. The results from the t-test are presented in Table 13 on the following page.

The results of the t-test suggest a significant difference in the mean time required to learn the basic system for each group. The results of the t-test were significant at the .0006 level. These results are consistent with the relationship suggested by the contingency table analysis in Table 12.

Viewing the contingency table analysis and t-tests together strongly suggests that there is a dependent relationship between time required to learn the basic system and type of computer used. In addition, one may conclude that users of graphical user interfaces in the organizations surveyed require significantly less time to learn the basic system than their counterparts using text-based user interfaces.

Table 13

T-Test Results for Type of Computer vs. Time Required to Learn the Basic System

Group	Count	Mean	Std. Dev.
MS-DOS users	197	2.594	1.504
Macintosh users	151	2.093	1.298

t value = 3.267

p = .0006

Note: Mean indicates response number, not hours

Investigative Question 2

To answer Investigative Question 2, the researcher used contingency table analysis and t-test comparisons for the average amount of time it took respondents to learn a new application program. As a supplement, the researcher also conducted similar analyses for specific types of applications to determine if learning time for each type of interface was task-dependent. The specific types of applications examined were word processing, spreadsheet, database, graphics/presentation, and CAD/CAM. Based on preliminary interviews with representatives at each of the organizations used in this research, the researcher found that these applications were common to each organization. The researcher also felt that these application areas offered the best opportunity to evaluate a wide range of tasks that are common in most of today's office environments.

To test whether time required to learn word processing was independent of type of interface used, the researcher used contingency table analysis. Table 14 below presents the observed and expected frequencies following the conventions presented for Investigative Question 1.

Table 14

Observed and Expected Frequencies for Computer Type vs. Time Required to Learn Primary Word Processing Application

Hours	MS-DOS users	Macintosh users	Totals
Less than 4	80 (102.56)	99 (76.44)	179
4-8	53 (53.29)	40 (39.71)	93
8-12	24 (17.76)	7 (13.24)	31
12-16	10 (8.59)	5 (6.41)	15
More than 16	45 (29.79)	7 (22.21)	52
Totals	212	158	370

Total Chi-Square = 35.467

p = .0001

Once again, the greatest discrepancies between observed and expected frequencies occur at the extreme ends of the response scale. For Macintosh users, there were more responses than expected below the 4 hour point, while there were fewer responses than expected above the 8 hour mark. MS-DOS responses were opposite of those found for Macintosh users reported above.

Based on the low p value associated with the contingency table, the researcher followed this analysis with a one-tail t-test to determine if the mean time required for command-based interface users to learn their primary word processing application was statistically different from the mean time for graphical user interface users. Table 15 below presents the results of the t-test.

Table 15

T-Test Results for Type of Computer vs. Time Required to Learn Primary Word Processing Application

Group	Count	Mean	Std. Dev.
MS-DOS users	212	2.684	1.964
Macintosh users	158	1.665	1.224

t value = 5.745

p = .0001

Note: Mean indicates response number, not hours

The t-test clearly shows a difference in the means for each group, indicating that MS-DOS users feel that it takes them longer to learn their primary word processing program than Macintosh users do. These results coupled with the contingency table analysis suggest that there may be a dependent relationship between type of computer used and time required to learn word processing applications.

The researcher then conducted similar analyses for spreadsheet applications. As in previous tables, the greatest differences between observed and expected values for this variable occurred at the extreme points of the rating scale. For example, only 53 MS-DOS users reported that it took them less than 4 hours to learn their primary spreadsheet program while 65.5 responses were expected. On the other hand, 68 Macintosh users were in the lowest category with only 55.5 responses expected. Conversely, at the top end of the scale, 28 MS-DOS users reported taking over 12 hours to learn their primary spreadsheet program with 19.49 responses expected in this category. Only 8 Macintosh users reported taking over 12 hours to learn their primary spreadsheet with 16.51 responses expected. Observed responses for the categories over 4 hours and less than 12 hours were more closely aligned with the expected number of responses in each respective category.

The results of the contingency table analysis are presented in Table 16 on the following page. Again, it was necessary to combine frequencies for responses 4-7 to meet the 5 observed responses per cell constraint needed for contingency table analysis.

Table 16

Observed and Expected Frequencies for Computer Type vs. Time Required to Learn Primary Spreadsheet Application

Hours	MS-DOS users	Macintosh users	Totals
Less than 4	53 (65.5)	68 (55.5)	121
4-8	36 (32.48)	24 (27.52)	60
8-12	14 (13.53)	11 (11.47)	25
More than 12	28 (19.49)	8 (16.51)	36
Totals	131	111	242

Total Chi-Square = 14.175

p = .0027

Due to the low p value, the researcher was able to conclude that computer type and time required to learn the user's primary spreadsheet program were not independent. The researcher then conducted t-tests to determine whether there was a difference in the mean time required to learn the user's primary spreadsheet program. Results of the t-test are shown in Table 17.

Table 17

T-Test Results for Type of Computer vs. Time Required to Learn Primary Spreadsheet Application

Group	Count	Mean	Std. Dev.
MS-DOS users	131	2.427	1.745
Macintosh users	111	1.73	1.265

t value = 3.504

p = .0002

Note: Mean indicates response number, not hours

The results of the t-test were consistent with what one might expect after viewing the contingency table. The researcher concluded that time required to learn the user's primary spreadsheet program was dependent on the type of computer used. In addition, the researcher concluded that users of graphical user interfaces feel that they require less time to learn spreadsheet applications than their counterparts using text-based interfaces.

As with word processing and spreadsheet applications, the researcher examined database applications using a contingency table. For the contingency table, responses 4-7 were combined with response 3 in order to meet the required 5 frequencies per cell. Required and expected frequencies are presented in Table 18 on the following page.

Table 18

Observed and Expected Frequencies for Computer Type vs.

Time Required to Learn Primary Database Application

Hours	MS-DOS users	Macintosh users	Totals
Less than 5	26 (32.73)	19 (12.27)	45
5-10	27 (27.64)	11 (10.36)	38
More than 10	43 (35.64)	6 (13.36)	49
Totals	96	36	132

Total Chi-Square = 10.703

p = .0047

Like tables for word processing and spreadsheet applications, the contingency table analysis for database established meaningful differences between observed and expected frequencies. Based on the low p value, the researcher was able to reject the hypothesis that time required to learn database programs and type of computer used were independent.

Because there was evidence to indicate possible dependency between the two variables, a one-tail t-test was run to detect differences between the mean responses for each group of users. Table 19 presents the results of this t-test.

Table 19

T-Test Results for Type of Computer vs. Time Required to Learn Primary Database Program

Group	Count	Mean	Std. Dev.
MS-DOS users	96	3.094	2.083
Macintosh users	36	1.639	.762

t value = 3.504

p = .0002

Note: Mean indicates response number, not hours

The results of the t-test were consistent with the finding for word processing and spreadsheet applications indicating a significant difference in the amount of time required to lea·n user's primary database application.

The researcher concluded that time required to learn the user's primary database application was dependent on the type of computer used. In addition, the researcher concluded that users of graphical user interfaces feel that they require less time to learn database applications than their counterparts using text-based interfaces.

The researcher then conducted the contingency table analysis for graphics/presentation programs using Table 20 on the following page. As with the tables presented earlier in the chapter, responses 5-7 were merged with response 4 to yield the required number of responses for contingency table analysis in each cell.

Table 20

Observed and Expected Frequencies for Computer Type vs. Time Required to Learn Primary Graphics/Presentation Application

Hours	MS-DOS users	Macintosh users	Totals
Less than 4	55 (70.1)	73 (57.9)	128
4-8	51 (56.4)	52 (46.6)	103
8-12	28 (23.55)	15 (19.45)	43
More than 12	50 (33.95)	12 (28.05)	62
Totals	184	152	336

Total Chi-Square = 26.958

p = .0001

Consistent with the results for each of the preceding applications, there are noticeable differences between actual and expected values for graphics/presentation programs. For times below 8 hours, text-based interface users have fewer responses than expected, while graphical interface users have more responses than expected. This situation is reversed for responses above 8 hours.

Based on the significance level (indicated by the p value) the researcher was able to reject the hypothesis that time requi d to learn

graphics/presentation programs and type of computer system used are independent. Because the researcher was able to reject the hypothesis of independence, he then conducted the t-test to further examine the nature of the relationship between the two variables. Table 21 presents the results of the one-tail t-test.

Table 21

T-Test Results for Type of Computer vs. Time Required to Learn Primary Graphics/Presentation Application

Group	Count	Mean	Std. Dev.
MS-DOS users	184	2.772	1.838
Macintosh users	152	1.888	1.274
t value = 5.014			
p = .0001			
Note: Mean indicates response number, not hours			

The results of the t-test show a clear difference in the means for MS-DOS and Macintosh users. The significance of the t-test in combination with the significance of the contingency table test for independence suggests that Macintosh users take less time to learn graphics/presentation programs than their MS-DOS user counterparts.

The final application-specific area that was examined was CAD/CAM software. Again, the researcher used a contingency table to test whether time required to learn CAD/CAM software is independent of type of

computer system used. The observed and expected frequencies are presented in Table 22. Here, responses 1 and 2 were combined as were responses 3-7 in order to yield the required 5 responses per cell needed for contingency table analysis.

Table 22

Observed and Expected Frequencies for Computer Type vs. Time Required to Learn Primary CAD/CAM Application

Hours	MS-DOS users	Macintosh users	Totals
0-10	19 (21.12)	9 (6.88)	28
More than 10	24 (21.88)	5 (7.12)	29
Totals	43	14	57

Total Chi-Square = 1.707

p = .1913

In contrast to the other applications examined, the researcher was not able to reject the hypothesis that time required to learn CAD/CAM software and type of computer system used are independent. Because potential dependency between the two variables could not be established, no t-test was conducted as any difference in the means would hold little practical meaning.

The final question respondents answered that was related to Investigative Question 2 asked computer users on the average how long it took them to learn a new application program. As in the application-specific questions, responses 4-7 had to be combined to yield at least 5 observed responses in each cell. Table 23 shows the observed and expected frequencies for average time required to learn a new application and the type of computer system used on the job.

Table 23

Observed and Expected Frequencies for Computer Type vs. Average Time Required to Learn a New Application

Hours	MS-DOS users	Macintosh users	Totals
Less than 4	71 (93.05)	90 (67.95)	161
4-8	67 (65.89)	47 (48.11)	114
8-12	31 (24.27)	11 (17.73)	42
More than 12	46 (31.79)	9 (23.21)	55
Totals	215	157	372

Total Chi-Square = 31.898
p = .0001

The greatest differences between observed and expected values was at the extreme ends of the response scale. The table shows that there were fewer responses below 4 hours for MS-DOS users than expected, while Macintosh responses were much higher than expected. This situation is reversed above 8 hours as MS-DOS users had higher observed frequencies than expected and Macintosh users had fewer responses in these categories than expected. This situation repeats a pattern observed in most of the application-specific questions.

The p value of .0001 allowed the researcher to reject the hypothesis that average time required to learn a new application and type of computer system used are independent. Because a majority of the application-specific areas also rejected the hypothesis of independence, one would expect a similar result for the more general question examined here.

Based on this evidence, the researcher then conducted the one-tail t-test to test whether the means for one user group was significantly higher than that of the other user group. The results of the t-test, as illustrated in Table 24, indicate that the mean for users of text-based interfaces is higher than the mean for users of graphics-based interface systems. The extremely low p-value of .0001 indicates a very low probability that the results indicated in the table occurred by chance.

The results of the t-test combined with the contingency table analysis presented in Table 23 strongly suggest that, on the average, applications employing graphical user interfaces require significantly less time to learn than applications using standard command-driven interfaces.

Table 24

T-Test Results for Type of Computer vs. Average Time Required to Learn a New Application

Group	Count	Mean	Std. Dev.
MS-DOS users	215	2.498	.112
Macintosh users	157	1.694	.093

t value = 5.247

p = .0001

Note: Mean indicates response number, not hours

In conclusion, there appears to be strong evidence that, for most applications, the amount of time required to learn that application is dependent on the type of interface used. For most applications, graphical user interfaces require significantly less time to learn than their text-based counterparts.

In particular, word processing, spreadsheet, database, and graphics/presentation programs seem to lend themselves particularly well to graphics-based interfaces. Only CAD/CAM programs appear to be independent of learning time. There was no evidence that text-based interfaces were better for any of the application areas examined in this study. On the average, users of graphical user interfaces reported that they required less time to learn a new application than did users of text-based systems.

Care should be used in interpreting the results for Investigative Question 2. Because of the differences in operating systems and software availability, it was not always possible to compare the same application for MS-DOS users and Macintosh users. To overcome this potential limitation, the researcher asked respondents to provide the name of the software package they used in each of the categories examined. In each case, popular and highly-rated commercial programs were the norm. For example, in the spreadsheet category the majority of MS-DOS users used Lotus 1-2-3, a package unavailable for the Macintosh. However, Macintosh users used the most popular Macintosh spreadsheet, Microsoft Excel, almost exclusively. Readers should be aware that because it was not always possible to compare identical vendors' products for each of the application areas, extreme care must be used in generalizing the results of this portion of the study to all situations.

Investigative Question 3

To answer Investigative Question 3, the researcher examined user responses to two questions for each interface type. For MS-DOS users, question 46 asked users to rate the ease of use of their system for performing basic file operations and question 47 asked users to rate the overall ease of use for their computer. Questions 54 and 55 asked the same questions respectively for Macintosh users. Responses to these questions were used to determine the overall user friendliness for each type of interface.

The researcher first examined observed and expected frequencies using a contingency table to test for variable independence. For ease of use in

performing basic file operations, 0 MS-DOS and Macintosh users chose response 1 (extremely difficult), 4 MS-DOS users and 0 Macintosh users chose response 2 (difficult), while 7 MS-DOS and 2 Macintosh users chose response 3 (moderately difficult). Because of the small number of users in these categories, particularly among Macintosh users, these responses were not reported in the table so as to maintain the minimum of 5 observed responses per cell. The researcher also felt that by not including these responses in the table, the reader was able to get more accurate representation of actual responses for each group by eliminating the distortion caused by combining categories over a wide range that included very few responses on the low end of the range. The researcher did combine responses 4 and 5 (moderate and moderately easy) to insure there were a minimum of 5 observed values in each cell. Table 25 shows the observed and expected frequencies for ease of use in performing basic file operations and computer used.

The values in the table show that MS-DOS users rated the ease of use for performing the basic file operations consistently lower than Macintosh users. For MS-DOS users, frequencies were higher than expected for the moderate to moderately easy range, while Macintosh responses were higher for the easy and extremely easy response categories. The extremely low p-value of .0001 indicated for the table allowed the researcher to reject the hypothesis that ease of use for performing the basic file operations and type of computer system used are independent.

Table 25

Observed and Expected Frequencies for Computer Type vs.

Ease of Use in Performing Basic File Operations

	MS-DOS users	Macintosh users	Totals
Moderate - moderately easy	88 (59.81)	18 (46.19)	106
Easy	73 (78.43)	66 (60.57)	139
Extremely easy	41 (63.76)	72 (49.24)	113
Totals	202	156	358

Total Chi-Square = 49.998

p = .0001

To further examine the relationship between these two variables, the researcher then performed a one-tail t-test to determine if the mean score for graphical interface users was higher than the mean score for text-based interface users on ease of use in performing basic file operations. Table 26 on the following page shows the results for this t-test. Note that all responses were considered in determining the mean responses for each group.

Table 26

T-Test Results for Type of Computer vs. Ease of Use in Performing Basic File Operations

Group	Count	Mean	Std. Dev.
MS-DOS users	213	5.446	1.175
Macintosh users	158	6.297	.786

t value = -7.892

p = .0001

The results of the t-test confirmed that users of graphical user interfaces in the organizations surveyed rate ease of use for performing basic file operations significantly higher than their counterparts using text-based interfaces. When contingency table and t-test results are considered together, there appears to be strong evidence that ease of use in performing basic file operations is not independent of type of computer system used and that users of graphics-based systems rate ease of use for basic file operations higher than users of text-based interfaces.

The researcher then examined the contingency table for overall ease of use for each type of computer system. Though not illustrated in the table for the reasons discussed in the previous analysis, 0 users in either group chose response 1 (extremely difficult), 3 MS-DOS users and 0 Macintosh users chose response 2 (difficult), and 4 MS-DOS users and 2 Macintosh users chose response 3 (moderately difficult). The researcher combined

responses 4 and 5 to insure there were a minimum of 5 observed responses per cell. Table 27 presents the results for this variable.

Table 27

Observed and Expected Frequencies for Computer Type vs. Overall Ease of Use

	MS-DOS users	Macintosh users	Totals
Moderate - moderately easy	114 (70)	12 (56)	126
Easy	60 (68.33)	63 (54.67)	123
Extremely easy	21 (56.67)	81 (45.33)	102
Totals	195	156	351

Total Chi-Square = 115.025

p = .0001

The pattern in Table 27 is identical to that in Table 25. MS-DOS users had higher than expected frequencies in the low ranges of the response scale while Macintosh users had higher than expected frequencies at the top of the scale. The low p value in this table again permitted the researcher to reject the hypothesis that the two variables examined are independent.

The researcher then performed the one-tail t-test to test if the mean score for MS-DOS users was actually lower than the mean score for

Macintosh users. Table 28 below presents the results for the t-test. Again note that all responses were considered in calculating the mean scores and are reported in the table.

Table 28

T-Test Results for Type of Computer vs. Overall Ease of Use

Group	Count	Mean	Std. Dev.
MS-DOS users	202	5.193	1.059
Macintosh users	158	6.392	.756
t value = -12.036			
p = .0001			

As in the contingency table, the results of the t-test for overall ease of use parallel those for the basic file operations shown in Table 26. The mean score for text-based interface users for overall ease of use was significantly lower than the mean score for graphics-based interface users in this study ($p = .0001$). Considered with the results of the contingency table, one can conclude that overall ease of use is not independent of computer system type and that users of graphical interface systems rate overall ease of use significantly higher than users of text-based interface systems.

The results from each of these tables allowed the researcher to conclude that graphical user interfaces have higher ratings of user-friendliness than text-based interfaces. For each of the questions examined, statistical tests consistently showed graphical user interfaces with higher levels of user-

reported ease of use ratings. Significance levels were consistently at the .0001 level, indicating strong support for the conclusions reported.

This section of the survey also asked users to rate the user-friendliness of specific aspects of using their computer system. Mean responses for questions 40-45 are reported for MS-DOS users in Table 29 below.

Table 29

Mean Responses for MS-DOS Operations

Type of Operation	Mean Response	Std Deviation
Using software commands	5.096	1.123
Using the keyboard	5.315	1.156
Working with the function keys	5.197	1.200
Recalling meanings of function keys	3.787	1.333
Learning the meanings of function keys	4.258	1.220
Moving the cursor to different points around the screen	5.571	1.222

Similarly, Table 30 on the following page reports responses for Macintosh operations measured by questions 48-53 in the Human-Computer Interface Survey.

The researcher did not do any further statistical analysis on these operations due to the difficulty in establishing a one-to-one relationship between the MS-DOS and Macintosh operations. Attempts to compare operations between the two systems should be done carefully. Any conclusions from these results are left to the reader.

Table 30

Mean Responses for Macintosh Operations

Type of Operation	Mean Response	Std Deviation
Working with the icons	6.416	.826
Understanding what icons represent	5.994	1.114
Working with the Macintosh windows	6.231	.979
Operating the mouse	6.563	.662
Learning to use the mouse	6.561	.760
Moving the cursor to different points around the screen	6.562	.661

Investigative Question 4

Investigative Question 4 examined whether users of one type of interface felt more strongly that their computer helps them perform in their job. The same statistical tests as were used in Investigative Questions 1-3 were used to answer Investigative Question 4.

Table 31 on the following page presents the observed and expected values for the perception that the computer system used helps users perform in their job and the type of computer system actually used. Note that 0 users in each group answered between the range of Response 1-Response 3 (strongly disagree-slightly disagree). Responses 4-5 were combined to yield the required 5 observed values per cell.

As illustrated in the table, observed responses on the lower end of the response scale were in the range that was expected. However, at the top

end of the response scale, Macintosh users chose the top value more often than expected and MS-DOS users were more inclined to choose response 6 over the highest value. Based on this contingency table, the researcher was again able to reject the hypothesis that users' perceptions that their computer system helps them perform in their job and type of system used are independent.

Table 31

Observed and Expected Frequencies for Computer Type vs. the Perception That Users' Computer System Helps Them Perform in Their Job

	MS-DOS users	Macintosh users	Totals
Undecided - slightly agree	7 (6.9)	5 (5.1)	12
Agree	85 (73.58)	43 (54.42)	128
Strongly agree	123 (134.52)	111 (99.48)	234
Totals	215	159	374

Total Chi-Square = 6.49

p = .039

Following the procedures used throughout the study, the researcher then conducted a one-tail t-test to detect whether the mean from one type

of interface was greater than the mean for the other type of interface. The t-test results are reported in Table 32 below.

The results of the t-test allowed the researcher to reject the hypothesis that the means were equal. Though both means were quite high for a 7-point scale, the evidence presented in Table 32 indicates that the mean value for Macintosh users is statistically higher than that for MS-DOS users.

Table 32

T-Test Results for Type of Computer vs. the Perception That Users' Computer System Helps Them Perform in Their Job

Group	Count	Mean	Std. Dev.
MS-DOS users	215	6.535	.578
Macintosh users	159	6.654	.584
t value = -1.962			
p = .0253			

From the results of the contingency table (Table 31) and the one-tail t-test (Table 32), the researcher concluded that users' perception of the extent to which their computer helps them in their job and type of computer used are not independent variables. On the other hand, while the difference between graphical and text-based interface users is statistically significant, the mean responses for each group were extremely high indicating that both sets of users felt very strongly that their computer helps them perform in their job. The practical difference between the two

means is arguable. Tests on related questions in the questionnaire yielded no statistical difference between each system, further indicating that both sets of users feel that their computer enhances their job performance.

Investigative Question 5

Investigative Question 5 examined whether there was a difference between types of interface used and the number of software packages used on the job. Because users who used only one software package were eliminated under the parameters established for this study, the minimum number of software packages used by any respondents was two. Table 33 presents the contingency table used for this analysis.

Table 33

Observed and Expected Frequencies for Computer Type vs. Number of Software Packages Used on the Job

Number	MS-DOS users	Macintosh users	Totals
2-3	68 (57.82)	32 (42.18)	100
4-6	84 (86.16)	65 (62.84)	149
More than 6	66 (74.02)	62 (53.98)	128
Totals	218	159	377

Total Chi-Square = 6.432

p = .0401

The table indicates that the number of software packages used on the job and type of computer system used are not independent. Though the p-value associated with this test is not as high as seen in previous tests, it nonetheless falls within the .05 significance levels established for this research. As one can see from the table, for responses 3 and 4, Macintosh users had higher than expected frequencies, while MS-DOS users had lower than expected frequencies. Likewise, for response 2, this pattern is reversed with MS-DOS users showing higher than expected frequencies.

To further examine whether the mean values for MS-DOS users was actually lower than that of Macintosh users, the researcher again performed a one-tail t-test on the data. Table 34 presents the results of the t-test.

Table 34

T-Test Results for Type of Computer vs. Number of Software Packages Used on the Job

Group	Count	Mean	Std. Dev.
MS-DOS users	218	2.991	.786
Macintosh users	159	3.189	.748

t value = -2.464

p = .0071

Note: Mean indicates response number, not number of software packages

The results indicated in Table 34 suggest that users of graphical interface systems use more software packages on the job than users of text-

based interfaces (p = .0071). The results of the t-test, coupled with the contingency table analysis presented in Table 33, indicate that the number of software packages used on the job is not independent of type of computer system used. In addition, the results of the tests conducted in this portion of the study indicate that users of graphical user interfaces use more types of software packages on the job than users of text-based interfaces in the organizations studied in this research.

Investigative Question 6

Investigative Question 6 tested whether users of one type of interface had higher levels of satisfaction with their computer system than users of the other type of interface examined in this study. 9 MS-DOS users strongly disagreed that they were extremely satisfied with their computer while 0 Macintosh users strongly disagreed. 7 MS-DOS users chose the disagree option compared with 1 Macintosh user. Finally, 17 MS-DOS users slightly disagreed while 3 Macintosh users chose this option. These responses are not reported in the table to provide a more accurate picture of the actual response categories while still maintaining the required 5 responses per cell. The researcher again felt that including these responses in aggregate form over a wide response range unfairly distorted the actual patterns of response. Table 35 presents the remaining observed and expected values for user satisfaction with their computer system and type of computer used on the job.

Table 35

Observed and Expected Frequencies for Computer Type vs. User Satisfaction With Their Computer System

	MS-DOS users	Macintosh users	Totals
Undecided	11 (8.64)	5 (7.36)	16
Slightly agree	49 (32.94)	12 (28.06)	61
Agree	83 (66.43)	40 (56.57)	123
Strongly agree	39 (73.99)	98 (63.01)	137
Totals	182	155	337

Total Chi-Square = 63.378
p = .0001

The significance level of the table (p = .0001) indicates that user satisfaction and type of computer are not independent. In examining values in the table, particularly at the high end of the scale, one can see that user satisfaction for Macintosh users was generally higher than expected and user satisfaction for MS-DOS users was generally lower than expected.

Since the two variables were not shown to be independent, the researcher conducted a one-tail t-test to determine if the mean satisfaction

rating for text-based interface users was significantly lower than the mean satisfaction rating for graphical interface users. Table 36 below presents the results of the t-test. Note that all responses were used in calculating the t-statistic.

Table 36

T-Test Results for Type of Computer vs.

User Satisfaction With Their Computer System

Group	Count	Mean	Std. Dev.
MS-DOS users	215	5.274	1.542
Macintosh users	159	6.396	.968

t value = -8.071

p = .0001

The results of the t-test indicate that the mean satisfaction level for Macintosh users is higher than the mean satisfaction level foı MS-DOS users in the organizations included in this study. The researcher was able to conclude that user satisfaction with their computer system was not independent of computer system used on the job and that graphical interface users have a higher level of satisfaction with their computer system than text-based interface users in the organizations surveyed in this study.

Investigative Question 7

As Whiteside has noted, it is difficult to separate the interface from the entire system for purposes of evaluation (27:185). Investigative Question 7 examined whether responsible authorities rated the quality of output higher for one system over the other system considered in this study. Survey respondents were asked if they supervised other personnel or if they were responsible for output generated by a computer. Individuals who responded affirmatively to either question were defined as responsible authorities for the purpose of this research. To answer Investigative Question 7, the researcher looked at responsible authorities' ratings of quality of text, quality of graphics, and overall document appearance for output generated by their computer system.

The first area studied was quality of text. Consistent with the methodology used throughout this study, the researcher first looked at expected and observed frequencies for quality of text and type of computer system used to test the two variables for independence. The contingency table used for this analysis is presented in Table 37 on the following page. Responses 1-5 were combined to allow at least 5 responses per cell in the table.

The table shows that Macintosh users had higher than expected ratings while MS-DOS users had lower ratings than expected. For example, 107 of the total 150 Macintosh responsible authorities gave their system the highest possible rating, while only 54 of a total 187 MS-DOS users gave their system the maximum rating. The low p value for the table allowed the researcher to reject the hypothesis that responsible authorities' ratings

of quality of text and type of computer system used on the job are independent.

Table 37

Observed and Expected Frequencies for Computer Type vs. Responsible Authorities' Ratings for Quality of Text

	MS-DOS users	Macintosh users	Totals
Very poor - above average	67 (41.62)	8 (33.38)	75
Good	66 (56.04)	35 (44.96)	101
Very good	54 (89.34)	107 (71.66)	161
Totals	187	150	337

Total Chi-Square = 70.159

p = .0001

The number of MS-DOS users in the lower categories was too large to eliminate from the analysis; however, the number of Macintosh users was so small that all of the lower categories had to be combined to meet the 5 observed responses per cell constraint. Table 38 provides a more detailed view of the actual response patterns in these lower categories and further highlights the magnitude of the differences in responsible authorities' ratings for quality of text.

Table 38

Detail of Responsible Authorities' Observed

Response Patterns for Quality of Text

	MS-DOS users	Macintosh users	Totals
Very poor	0	0	0
Poor	1	0	1
Below average	11	0	11
Average	32	4	36
Above average	23	4	27

Based on the results of the contingency table analysis, the researcher conducted a one-tail t-test to see if the mean rating for users of text-based interfaces was significantly lower than the mean rating for users of graphics-based systems. Table 39 presents the results of the t-test.

The t-test indicates a significant difference in the means and suggests that users of graphics-based systems feel that their system delivers better quality output for text than users of text-based systems.

Considered with the results of the contingency table analysis, the researcher concluded that responsible authorities' rating of text quality is not independent of type of computer system used on the job and that users of graphics-based system rate the quality of text produced by their system higher than users of command-driven interfaces rate quality of text produced by their system..

Table 39

T-Test Results for Type of Computer vs.

Responsible Authorities' Ratings for Quality of Text

Group	Count	Mean	Std. Dev.
MS-DOS users	187	5.626	1.257
Macintosh users	150	6.633	.670
t value = -8.861			
p = .0001			

Next, the researcher looked at quality of graphics produced by each type of system. The methodology used for this portion of Investigative Question 7 was identical to that used in examining quality of text output. Table 40 presents the contingency table used in this analysis. Again, a large number of categories in the lower ranges of the response scale had to be combined for meaningful analysis.

The pattern in Table 40 is nearly identical to that in Table 37. Again, responsible authorities using the Macintosh system rate the quality of graphic output produced by their system higher than expected while responsible authorities using the MS-DOS-compatible systems had lower ratings than were expected. As an example, 105 of 149 Macintosh users gave their system the highest possible rating. In contrast, only 35 of 182 MS-DOS users gave their system the highest rating. Based on this analysis, the researcher was able to reject the hypothesis that responsible authorities'

ratings of output quality is independent of type of computer system used on the job.

Table 40

Observed and Expected Frequencies for Computer Type vs. Responsible Authorities' Ratings for Quality of Graphics

	MS-DOS users	Macintosh users	Totals
Very poor - above average	84 (50.59)	8 (41.41)	92
Good	63 (54.44)	36 (44.56)	99
Very good	35 (76.98)	105 (63.02)	140
Totals	182	149	331

Total Chi-Square = 102.879

p = .0001

Again, the large number of MS-DOS users in the lower ranges of the scale was too large to eliminate from the analysis while the few number of Macintosh users in the same range forced the researcher to combine a large number of response categories. Table 41 provides a more detailed look at the actual response patterns for these ranges and further highlights the differences between each of the two groups.

Table 41

Detail of Responsible Authorities' Observed

Response Patterns for Quality of Graphics

	MS-DOS users	Macintosh users	Totals
Very poor	1	0	1
Poor	6	0	6
Below average	19	0	19
Average	39	3	42
Above average	19	5	24

Following the prescribed methodology, the researcher next conducted a one-tail t-test on the data to establish whether the mean rating for one interface was statistically different than the mean rating for its counterpart. Table 42 shows the results from the t-test conducted using this data.

The results from this t-test parallel those found for quality of text ratings. The results suggest that users of graphics-based systems rate the quality of graphics produced by their system significantly higher than users of text-based systems.

After analyzing the contingency table and t-test for responsible authorities' ratings of quality of graphic output, the researcher concluded that quality of graphics and type of system used on the job are not independent and that responsible authorities rate the graphics produced by

graphical interface systems higher than the graphic output produced by text-based interfaces.

Table 42

T-Test Results for Type of Computer vs.

Responsible Authorities' Ratings for Quality of Graphics

Group	Count	Mean	Std. Dev.
MS-DOS users	182	5.187	1.452
Macintosh users	149	6.631	.651

t value = -11.247

p = .0001

The final area studied as part of Investigative Question 7 was overall document appearance. The contingency table used for the initial analysis is presented in Table 43 on the following page. The pattern of the results was consistent with the two previous contingency tables in this section of the study. Responsible authorities who used the Macintosh system once again rated the overall document appearance higher than expected while MS-DOS users rated the overall appearance of documents produced by their system lower than expected. 111 of the total 148 Macintosh users gave their system the highest possible rating, while only 35 of 183 MS-DOS users gave their system a rating of 7. Based on the p value for the contingency table,

the researcher rejected the hypothesis that overall document appearance and type of computer system used are independent.

Table 43

Observed and Expected Frequencies for Computer Type vs. Responsible Authorities' Rating: for Overall Document Appearance

	MS-DOS users	Macintosh users	Totals
Very poor - above average	68 (40.36)	5 (32.64)	73
Good	80 (61.92)	32 (50.08)	112
Very good	35 (80.72)	111 (65.28)	146
Totals	183	148	331

Total Chi-Square = 112.055

p = .0001

As in the previous tables in this section, the number of MS-DOS users in the lower response ranges was too large to eliminate from the analysis. However, the few Macintosh users in these same ranges forced the researcher to combine a large number of categories. Table 44 provides a more accurate view of the actual response patterns in the lower ranges of the response scale.

Table 44

Detail of Responsible Authorities' Observed

Response Patterns for Overall Document Appearance

	MS-DOS users	Macintosh users	Totals
Very poor	0	0	0
Poor	1	0	1
Below average	12	0	12
Average	30	3	33
Above average	25	2	27

The researcher then conducted a one-tail t-test to test for differences in the mean values for each type of system. The results of the t-test are presented in Table 45 below.

Table 45

T-Test Results for Type of Computer vs.

Responsible Authorities' Ratings for Overall Document Appearance

Group	Count	Mean	Std. Dev.
MS-DOS users	183	5.508	1.195
Macintosh users	148	6.696	.602

t value = -11.014

p = .0001

Consistent with the results reported earlier in this section, the t-test indicated that responsible authorities' ratings for overall document appearance for graphics-based systems was significantly higher for graphics-based systems than text-based systems ($p = .0001$). Based on the results of the contingency table and the t-test, the researcher concluded that overall document appearance is not independent of type of computer system used and that responsible authorities rate the overall appearance of documents produced by graphical systems significantly higher than the overall appearance of documents produced by text-based systems.

For Investigative Question 7, each of the areas studied (quality of text, quality of graphics, and overall document appearance) led the researcher to conclude that the quality of output for graphics-based systems is rated much higher than the quality of output for text-based interface systems by responsible authorities in the organizations surveyed in this research. Each statistical test yielded a significance level much higher than could be expected to occur by chance.

Investigative Question 8

Investigative Question 8 examined the nature of the relationship between users' job experience level and type of interface used on the job. To look at how experience level affected type of computer used on the job, the researcher examined the relationships between both the time in the job and type of computer used, and the respondents' grade and type of computer used. Because the questions used for this portion of the study were demographic in nature, the researcher limited his statistics to contingency table analyses to test for independence.

The first variable examined was time in job. Table 46 presents the contingency table used for the analysis of this variable. Table 46 shows that respondents with less than two years on the job used the Macintosh system more frequently than expected while respondents with more than three years on the job used MS-DOS-compatible systems more frequently than was expected.

Table 46

Observed and Expected Frequencies for Computer Type vs. Respondents' Time in Job

Years	MS-DOS users	Macintosh users	Totals
Less than 1	39 (46.17)	41 (33.83)	80
1-2	35 (45.59)	44 (33.41)	79
2-3	33 (33.47)	25 (24.53)	58
3-4	39 (31.74)	16 (23.26)	55
More than 4	71 (60.02)	33 (43.98)	104
Totals	217	159	376

Total Chi-Square = 17.143

p = .0018

The p value associated with the table allowed the researcher to reject the hypothesis that time in the job and type of computer system used are independent. It appears from the results of the table that users with less time on the job are more likely to use the graphics-based system while users with over three years on the job use the text-based interface in greater numbers.

The researcher then looked at military status and type of computer used on the job to determine if there were any potential dependencies on military status as part of the overall user experience level. Table 47 shows the observed and expected values for military status and type of computer used on the job.

Table 47

Observed and Expected Frequencies for Computer Type vs. Respondents' Military Status

Military Status	MS-DOS users	Macintosh users	Totals
Military	51 (74.16)	78 (54.84)	129
Civilian	164 (140.84)	81 (104.16)	245
Totals	215	159	374

Total Chi-Square = 25.967

p = .0001

The pattern of results illustrated in Table 47 would seem to indicate that military users use the Macintosh more often than expected, while civilian users use MS-DOS-compatible systems in higher numbers. This marked difference may initially appear surprising. However, the results from this table may be related to the results from Table 46 which examined respondents' time in job.

The researcher analyzed the data and determined that time in present job is dependent on military or civilian status. The mean time in job for military respondents was just over one year, while civilian users had a mean time in their present job of well over two years.

Table 48 presents the contingency table used for this analysis. One can see by examining the table that there were a total of 81 military users with less than 2 years of experience while only approximately 55 responses were expected in these categories. On the other hand, in the upper range of the response scale, there were a total of 130 civilians with at least 3 years of experience with only slightly over 103 responses expected in these categories.

Given these findings, the results from Table 47 are consistent with the results from Table 46, which indicated users with less time in their job used the Macintosh in greater numbers than were expected. The significance level of the contingency table analysis ($p = .0001$) allowed the researcher to reject the hypothesis that grade and type of computer system used are independent.

Table 48

Observed and Expected Frequencies for Military Status vs.

Time in Job

Time in Job	Military	Civilian	Totals
Less than 1 year	43 (27.67)	37 (52.33)	80
1-2 years	38 (27.32)	41 (51.68)	79
2-3 years	20 (19.37)	36 (36.63)	56
3-4 years	13 (18.68)	41 (35.32)	54
4 years or more	15 (35.97)	89 (68.03)	104
Totals	129	244	373

Total Chi-Square = 40.723

p = .0001

Tables 46 and 47 indicate that users' job experience level and type of computer system used are not independent. The researcher concluded that users with less experience were more likely to use graphical interface systems while users with higher experience levels used text-based interfaces in higher numbers. In addition, military users were more likely to use graphics-based systems and civilians tended to use text-based

systems more than was initially expected. However, readers must be extremely cautious in interpreting the results presented for Investigative Question 8 so as not to assume dependencies or causal relationships that may not actually exist.

Summary

Chapter 4 has presented data analysis for this study. With the exception of Investigative Question 8, the researcher used a combination of contingency table analysis and t-test results in order to present the most complete analysis possible for the data used in this research. Investigative Question 8 used only contingency tables to test for independence due to the demographic nature of the variables examined.

In Chapter 4, each investigative question was reported as a separate entity. In reality, each separate investigative question forms only part of the overall picture for this research. While the answers to each investigative question are significant, readers must not place undue emphasis on any individual investigative question or on one statistical test. Chapter V will attempt to integrate the investigative questions in order to attach meaning to the results reported in Chapter IV and arrive at some overall conclusions and implications for this research.

V. Conclusions and Recommendations

Chapter 5 presents the researcher's conclusions and recommendations based on the data anaiysis presented in the previous chapter. Chapter V will review the findings for each of the investigative questions in an attempt to integrate these findings to answer the research question for this study. The chapter will then discuss potential implications from these conclusions and their impact on Air Force information resource managers. Finally, the chapter will present several recommendations for future research.

Conclusions

The research question used for this research was as follows:

What are the advantages and disadvantages of graphical, mouse-driven user interfaces as compared to character-based, command-driven user interfaces, and what is each system's impact on measures of job efficiency and job effectiveness within the Air Force?

Eight investigative questions were developed to answer the research question presented above. The conclusions reached for each of the investigative questions directly impact the overall conclusions reached in answering the research question. Because of the central importance of each investigative question, it is important to review the conclusions for each of the investigative questions here, before addressing the research question.

Investigative Question 1 studied how each type of interface compared in the amount of time required to learn the basic system. From the data gathered in the questionnaire, the researcher concluded that users of

graphical interface systems required significantly less time to learn the basic system than users of text-based systems. Consistent with this conclusion, there was strong evidence to indicate that the amount of time required to learn the basic system was dependent on the type of computer system (graphics or text-based) used on the job. Figure 1 indicates the mean responses to the questionnaire for each type of system.

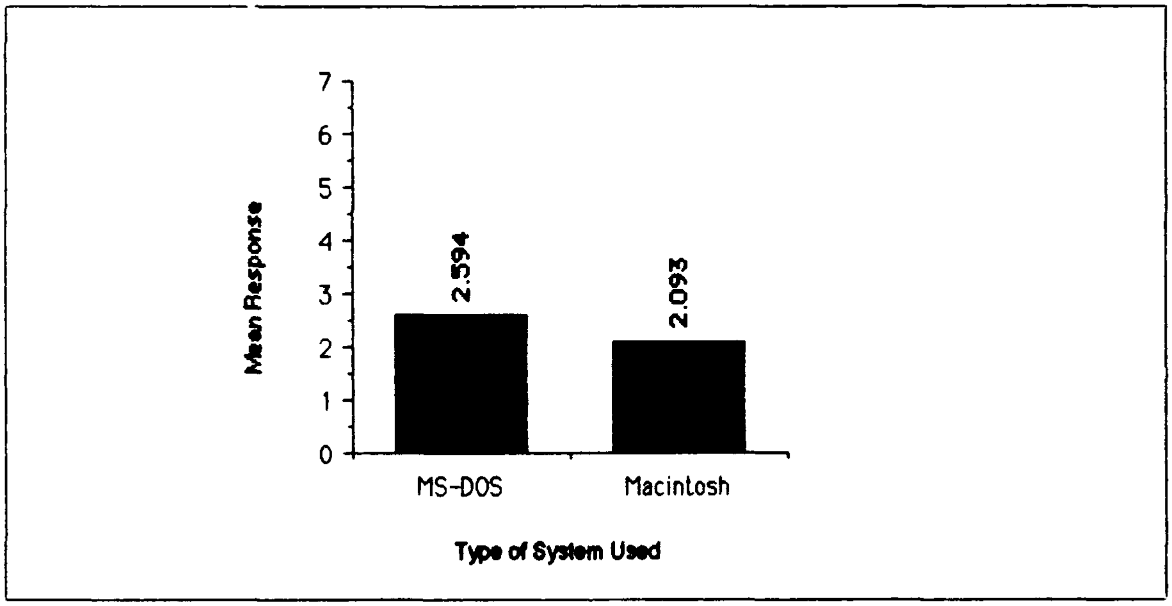

Figure 1. Mean Responses for Each System for Time Required to Learn the Basic System

Given that graphical user interfaces require less time to learn the basic system, the researcher then examined whether there were differences in the amount of time required to learn different applications programs. The researcher chose to look at word processing, spreadsheet, database, graphics/presentation, and CAD/CAM applications. In addition, the researcher asked respondents to choose the amount of time, on the average, that it took them to learn a new application program.

The results for Investigative Question 2 were somewhat surprising. For word processing, spreadsheet, database, and graphics/presentation applications, graphics-based systems maintained a clear advantage in learning time over text-based systems. Figure 2 presents the mean scores for each of these applications for each type of system. Again, there was strong evidence that learning time for each of these applications was dependent on the type of computer system used. In each case, the graphics-based system required significantly less time to learn than text-based systems.

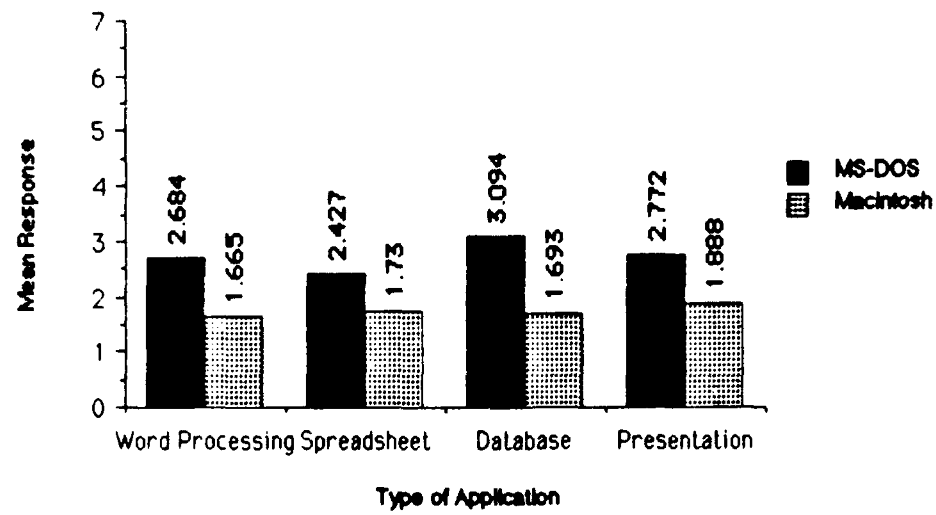

Figure 2. Mean Responses for Each System for Time Required to Learn Specific Applications

However, there was no evidence of such dependency for CAD/CAM applications. One might expect that text-based systems might maintain an

edge in some of the application areas studied here—particularly those areas (such CAD/CAM) where there has been a void (until recently) in the number of quality products for graphics-based systems available. However, there was no evidence in this study to support an advantage for text-based systems in learning time for any of the application areas studied.

For the five specific areas studied, graphical systems offered a clear advantage in four areas while one area showed no statistical difference. Finally, when asked on the average how long it took them to learn a new application program, users of graphics-based systems again required much less time than did users of text-based systems. These results indicate that, for most applications, graphics-based systems offer significant advantages in the amount of time required to learn new software packages. For other application areas, there was no apparent difference between text and graphics-based systems.

Investigative Question 3 compared users' ratings of user-friendliness for each type of system. To examine user-friendliness, the researcher looked at ease of use for a list of basic file operations and overall ease of use. Based on the results discovered for Investigative Questions 1 and 2, it was not surprising to again find that graphical user interfaces were rated significantly higher in users' ratings of user-friendliness. User-friendliness has long been listed as one of the primary advantages of graphics-based computer systems by the manufacturers of these systems. For the organizations used in this study, such claims appear to have merit. The data gathered in this research suggested that users' ratings of user-friendliness were dependent on the type of computer system used on the job. Figure 3

below illustrates the mean responses for each area evaluated for Investigative Question 3.

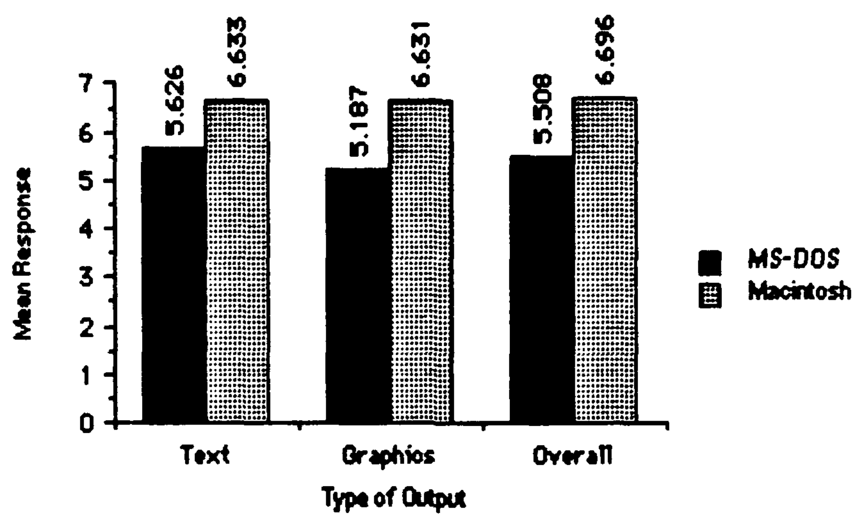

Figure 3. Mean Responses for Each System for User-Friendliness

Investigative Question 4 researched how each type of interface affected users' perceptions that their computer helps them perform in their job. Just because a system is easy to learn, or is rated higher in abstract concepts such as user-friendliness, does not necessarily translate into increases in productivity. However, if users report that one type of system helps them perform in their job more than an alternative system, then it is likely that users of that system will be more productive than users of the other type of system. Once again, graphical user interfaces offered a statistically significant advantage over text-based interfaces. There was evidence that users' perceptions of the extent that their computer helps them perform in

their job was dependent on the type of computer system they used on the job. Figure 4 illustrates the extent to which each set of users felt that their computer system helps them perform on the job. Though the means for each system appear close, the difference was significant at the .0173 level. The researcher concluded that users' of graphics-based systems feel more strongly that their computer helps them perform in their job. However, in real-world terms it is arguable whether a difference of 6.654 to 6.535 on a scale of 7 would be noticeable in terms of higher productivity levels. The fact that the means for each group are extremely high indicates that both sets of users feel that their computer plays a critical role in helping them perform on the job.

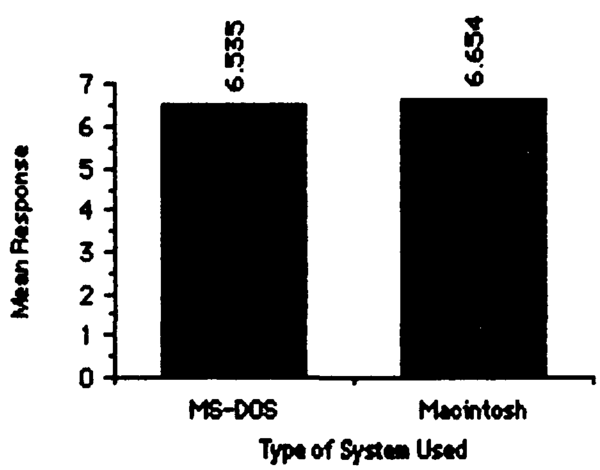

Figure 4. Mean Responses for Each System for the Amount Computer Helps Users Perform In Their Job

Research Question 5 studied another area of potential productivity gains by documenting how each type of interface affected the number of

software packages users of that system used on the job. Probably as a result of the training and user-friendliness issues discussed above, graphical interfaces were statistically higher in this category as well. Consistent with earlier results, there was evidence to suggest that the number of software packages used was dependent on the type of computer system used on the job. In addition, the mean number of software packages used was significantly higher for graphical interface users over users of text-based systems. Figure 5 illustrates the mean responses for each type of system. The difference illustrated was significant at the .0071 level.

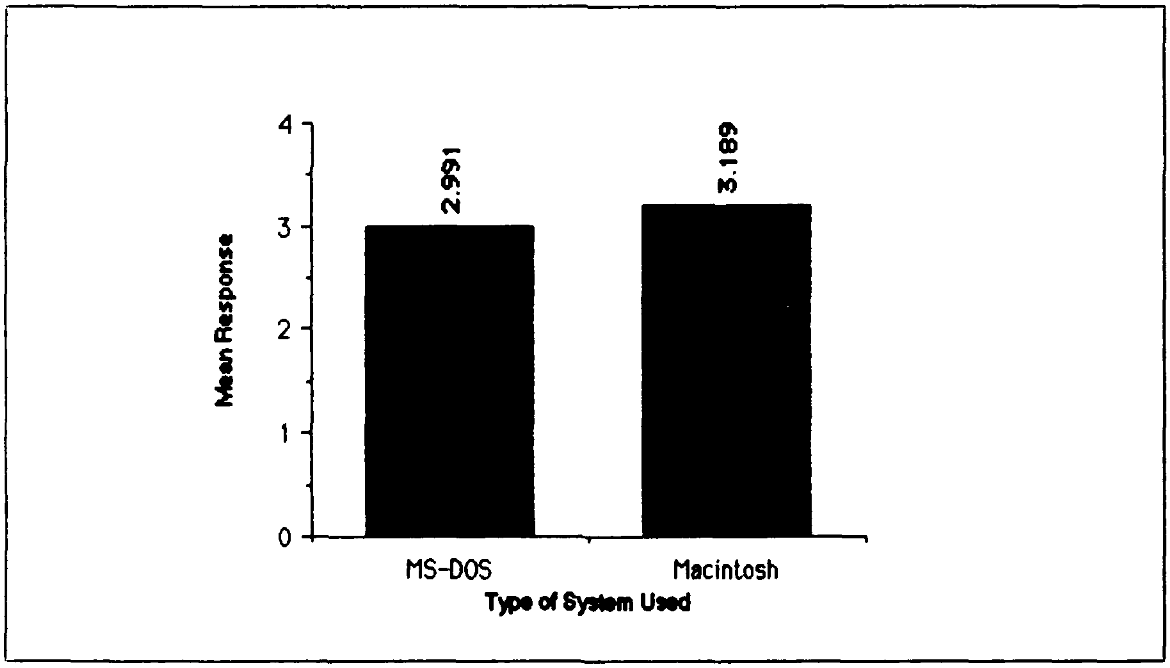

Figure 5. Mean Responses for Each System for the Number of Software Packages Used on the Job

This result may be related to the training and user-friendliness issues examined in Investigative Questions 1-3. If users are able to learn their

system or an application faster, it would seem likely that they would be more willing and able to learn a larger number of software packages. Also, systems which are perceived as user-friendly may be less intimidating to use, leading to a higher number of software packages used on the job.

Again, one must be cautious in necessarily attributing productivity gains to the number of software packages used on the job. While certainly possible, productivity increases as a result of the differences in number of software packages used is likely dependent on what particular software packages are being used at the margins. For example, if Macintosh users use an additional graphics package, or filing system that MS-DOS users do not use, then it may be reasonable to assume that gains in productivity will result. On the other hand, if the additional software packages are clock programs, screen savers, etc., then attributing gains in productivity to the use of these programs is risky at best. Given the difference in the number of software packages used, the types of programs used by each group of users, particularly at the margins, may be an area for further study.

Investigative Question 6 examined user satisfaction levels with their computer system. If users are satisfied with the system they use, one might expect that the productivity would be greater than for users of a system perceived as unsatisfying. A system which is satisfying to use reinforces using that system to automate as many appropriate functions as possible (remembering that it may not be appropriate to automate some functions). Based on the results reported earlier, it was not surprising that graphics-based systems have much higher levels of user satisfaction in the organizations used in this research. Figure 6 presents the mean responses for user satisfaction with their computer system. It appears that the level of

satisfaction is dependent on the type of computer system used, with users of graphics-based systems reporting much higher levels of satisfaction with their system.

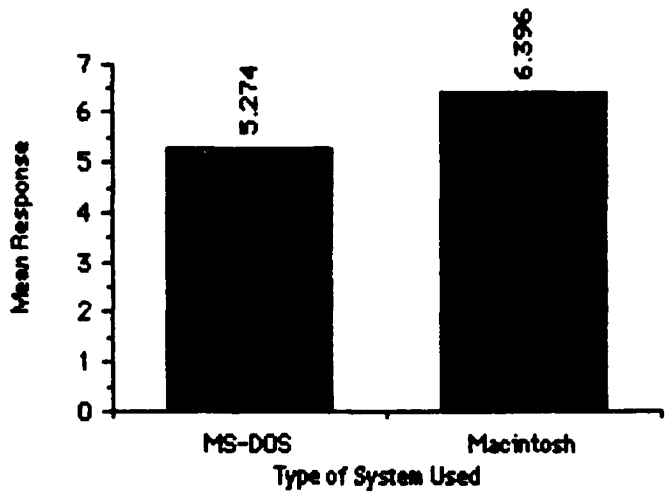

Figure 6. Mean Responses for Each System for User Satisfaction Level

Investigative Question 7 asked responsible authorities to rate the quality of output generated by the system they used or were responsible for. To address this issue, the researcher examined quality of text, quality of graphics, and overall document appearance as measures of output quality. In each of the three cases, graphics-based systems had significantly higher ratings than did text-based systems. There was strong evidence to indicate dependency between each of the three variables and type of computer system used. In addition, the mean scores for each area illustrated a clear advantage for the graphics-based system. Figure 7 illustrates the results for each category examined. The researcher concluded that responsible

authorities in the organizations surveyed rate graphics-based systems much higher for output quality than text-based systems.

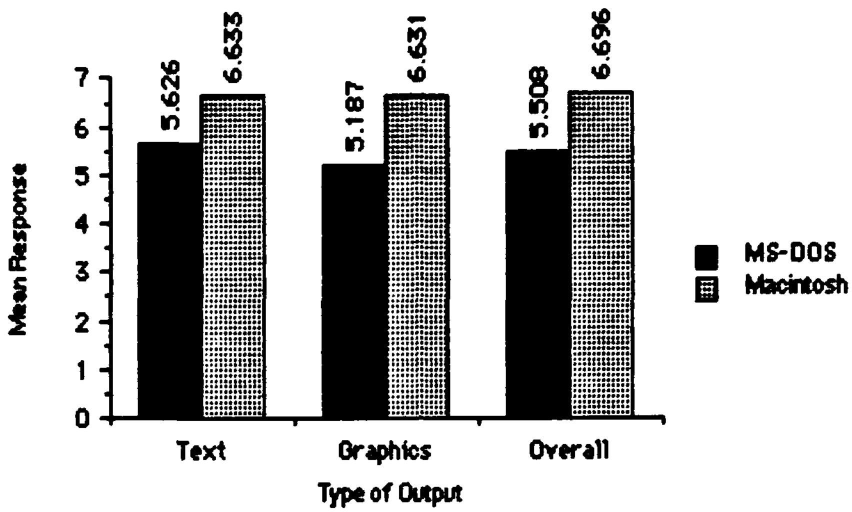

Figure 7. Mean Responses for Responsible Authorities' Ratings of Quality of Output

Primarily due to the training and user-friendliness findings, Investigative Question 8 used some of the user demographics to determine the nature of the relationship between user experience level and the type of interface used on the job. Specifically, the researcher checked to see how long a user had been in his job affected the type of system used on the job. In addition, the researcher checked to see how respondents' military status affected the type of system used on the job.

There was evidence to indicate that the amount of time in the job and type of interface used were dependent. Users who had been in their job for less than two years tended to use the graphical user interface. On the other hand, users who had been in their job over three years tended to use the more traditional command-driven interface.

Examining the data for military status and type of system used produced the most surprising results of the study, in the researcher's opinion. There was strong evidence to indicate that military users used a disproportionate number of graphics-based systems while civilian users used a higher number of text-based interfaces. Given the large number of text-based systems currently within use in the Air Force, this result was not expected and has important implications for information resource managers, particularly within the Air Force.

The researcher concluded that users' experience level does impact the type of interface used on the job. Users with less job experience tend to use graphics-based systems while users with more job experience used text-based systems in higher numbers. In addition, evidence gathered from this study supported the hypothesis that the military status of survey respondents and type of computer system used on the job were not independent.

Each of these independent questions addresses a separate facet of the larger research question. To answer the research question, the researcher used the inputs from the separate investigative questions to form a macro view of the entire problem domain. The researcher then conducted a subjective analysis to arrive at the overall conclusions for the research question.

The consistent pattern of results for each investigative question cannot be ignored. In each case, graphical user interfaces provide important advantages which must be considered by the information resource manager. Among the more tangible advantages is training time. Both for learning the basic system, as well as learning most types of application programs, graphical user interfaces require significantly less time to learn than text-based systems. Another more tangible benefit supported by the data analysis is that users of graphical user interfaces use more software packages on the job. As stated earlier, this may be related to training time and other more intangible measures of user acceptance.

There were also three more intangible benefits to graphical user interfaces. First, users of graphics-based systems give their system much higher ratings of user-friendliness than text-based interface users give their system. One would expect that systems which are more user-friendly are also more reinforcing to use and less subject to user resistance. Second, users of graphics-based systems feel slightly more strongly that their computer helps them perform their jobs. In a related finding, users of graphical interface systems are more satisfied with their computer system than their counterparts. While only perceptions, these findings have important productivity implications as workers who are more satisfied with their computer system and feel that it helps them in their job are likely to use their computer system to its maximum potential. The final intangible area addressed in this study was responsible authorities' ratings of output quality. The results of this study strongly suggest that the appearance of documents (both text and graphics) produced by graphics-based systems is superior to the appearance of documents produced by text-based systems.

Responsible authorities' output ratings appear to be dependent on the type of system used to produce that document.

Finally, there is evidence indicating that graphical user interfaces are particularly suited to individuals with lower experience levels on the job, typically those with less than two years' experience on the job. Most surprisingly, a disproportionate number of military users used the graphics-based system. For organizations with similar demographics to those presented here, graphical user interfaces may overcome some of the difficulties, particularly in the training arena, often experienced by information resource managers.

The results of this study uncovered no disadvantages to graphical user interfaces. Readers should not misinterpret this to mean that there are no disadvantages to graphics-based systems—only that there were no disadvantages in the narrow set of variables examined in this study. It is important to note that this study did not address networking or compatibility concerns. It is entirely possible that text-based systems may offer important advantages in these areas.

Another critical factor which was not addressed is cost. In many cases, graphical user interfaces have a higher initial (purchase) cost than text-based systems. Obviously, in many cases, initial cost may be the single most important concern. In such cases, the traditional cost-benefit analysis is probably more relevant to the sponsoring organization than the results presented here. However, training, support, and productivity costs may favor graphical user interfaces if cost is viewed from a life-cycle perspective.

It is also important to note that this research is based on an intensive analysis of two unique organizations at Wright-Patterson AFB. While care was taken to insure that the tasks performed in these organizations was fairly typical of other Air Force organizations, there are always dangers associated with over-generalizing the results of specific research to populations with an organizational structure unlike those studied in this research. Any conclusions drawn for organizations not included in this study must be done carefully.

Implications

The results of this research contain important implications for Air Force information resource managers, particularly in an era of diminishing financial and personnel resources. The first area is training. Other theses at the Air Force Institute of Technology are currently underway to examine the status of computer training and are beyond the scope of this research. However, the results of this research impact the training arena. As reported earlier, graphical user interfaces offer significant advantages in both the amount of time required to learn the basic system and time required to learn new applications programs. It is not uncommon for low-cost microcomputer resources purchased with grand intentions to remain virtually unused because the personnel responsible for operating those systems are either unable or unwilling to learn the operating system and/or software packages for that microcomputer. To compound this problem, the Communications (SC) and Information Management (IM) functional communities have not been able to provide an adequate level of training to overcome the natural resistance that is associated with change. Formal

training programs are expensive to develop, operate, and maintain. In an era of shrinking budgets, most organizations simply do not have the funds available to dedicate to computer training. Graphical user interfaces may provide the answer to these problems. Because they require less time to learn and are easy to use, formal training programs become less important. The intuitive nature of graphical user interfaces allow users to essentially train themselves. The amount of time spent in training is dramatically reduced, potentially providing a requisite increase in productivity.

The second important implication focuses on the job experience and grade demographics discussed earlier. Because of the relatively large degree of turnover in military work-centers, there is always a significant number of personnel with less than two years experience in the job. This may explain why military users use a disproportionate number of graphics-based systems. Because today's Air Force work-center almost always includes both inexperienced and military users, an interface which is well-suited to this population would seem to offer the potential for increased productivity. Again, the training issue becomes a central concern. Because military members turnover quite frequently, formalized training classes often lose their impact after one or two years as the people who received the training rotate to new assignments. For relatively inexperienced and/or military users, graphical user interfaces offer an environment which supports rapid, individualized learning.

These are just two implications which Air Force information resource managers must consider in completing systems requirements analysis. While text-based systems typically offer a lower initial or purchase cost, information managers must consider organizational dynamics as well to

determine if, in the long run, text-based interface systems continue to provide the most cost-effective solution.

Suggestions for Future Research

The results reported in this study should not be interpreted as an endorsement for a particular graphical user interface or manufacturer. Rather, this research should stimulate discussion and further analysis of the benefits and disadvantages associated with graphical user interfaces. In particular there are several areas which may merit future study.

The research presented here focused on two unique organizations at Wright-Patterson AFB. Based on the results of this study, it would be appropriate to test whether the results obtained in this study could be replicated across a larger Air Force or Department of Defense population. At the time of this research, there were very few organizations in the mainstream of the Air Force that used both graphical and text-based interfaces in their daily computing operations. In all likelihood, as graphical user interfaces gain in popularity, a larger number of organizations with an even greater degree of functional diversity will be available to test the results of this study.

Second, as more graphical user interfaces are implemented, it would be appropriate to test a number of graphical user interfaces and text-based interfaces. As stated in the methodology established for this study, the Apple Macintosh system was chosen as a representative for all graphical interfaces out of necessity. At the time of the study, there were very few applications programs available for graphics-based systems except the Macintosh. As systems such as Windows 3.0, as well as others, become

more available, the amount of software available will increase to an acceptable level. Research is needed to identify whether the results of this study can be applied to all graphical user interfaces, or whether different graphical user interfaces perform differently.

Finally, research into the life-cycle cost of graphics-based systems as compared to text-based systems would be useful. Too often, the purchase price is the only variable considered in choosing microcomputer resources. Given the benefits presented here, research is now needed to determine which type of system provides the most cost-effective solution over the life-cycle of each system.

Summary

There appears to be strong evidence that graphical user interfaces offer significant advantages to users of such systems. Graphical user interfaces consistently outperformed text-based systems in training time, user-friendliness, user satisfaction, number of software packages used, perceived job performance, and output quality. These results have important implications for future Air Force microcomputing requirements.

The results presented here suggest a serious need for future study in this area. For many organizations, the benefits gained from adopting a graphical environment may outweigh the initial cost associated with many graphics-based systems. As graphical user interfaces increase in popularity, future studies should attempt to determine whether there are differences between graphical user interfaces, or whether the results presented here may be generalized to all graphics-based systems.

The question now shifts from whether some graphical user interfaces offer advantages over command-driven interfaces to whether the advantages reported here are worth the associated additional initial cost. Air Force information resource managers must consider the benefits reported here if their organization is to continue to meet mission requirements in an era when constraints on budgetary and personnel resources are likely to increase.

Instructions for Completing the Human-Computer Interface Survey

1. Thank you for taking the time to complete this survey. Attached you should find a questionnaire, an answer sheet (AFIT Form 11C), and a return envelope.

2. Please answer all questions (with the exception of the last 4) on the computerized answer sheet provided. Use only a number two pencil in filling in the number of the appropriate response.

3. Do not fill in your name or social security number on the answer sheet. Your answers will be combined with others and will not be attributed to you personally.

4. Be sure to read the directions for each section carefully. Depending on the type of computer you use, you will be asked to answer different sections of questions. This is clearly explained in the directions preceding each section of the questionnaire. When skipping over different sections, be sure your answers on the answer sheet match the question you are actually answering on the questionnaire.

5. Once you have completed the survey, place the questionnaire and your answer sheet in the return envelope provided. It is important that you not fold or staple your answer sheet when returning it. If you have lost the return envelope, please return them through the base distribution system to the following address:

Capt Michael G. Morris
AFIT/LSG
Wright-Patterson AFB, OH 45433

6. Again, thank you for taking a few minutes to assist with this research. Your response will help us assess the impact different human-computer interfaces have in the Air Force office environment.

HUMAN-COMPUTER INTERFACE SURVEY

Section 1: Please answer the following demographic questions on the answer sheet provided.

1. With which organization are you employed?
   1. Advanced Tactical Fighter SPO
   2. Wright Research and Development Center

2. Which category best describes your primary job?
   1. secretarial
   2. administrative
   3. management
   4. engineering
   5. finance/cost
   6. computer operations
   7. security
   8. other

3. What is your grade?
   1. E1 - E3
   2. E4 - E6
   3. E7 - E9
   4. O1 - O3
   5. O4 - O5
   6. O6 or above
   7. GS-1 - GS-7
   8. GS-8 or above

4. What is the total length of time that you been employed by the federal government?
   1. less than 1 year
   2. at least 1 but less than 3 years
   3. at least 3 but less than 5 years
   4. at least 5 but less than 8 years
   5. at least 8 but less than 12 years
   6. 12 years or more

5. How long have you been in your present job?
   1. less than 1 year
   2. at least 1 but less than 2 years
   3. at least 2 but less than 3 years
   4. at least 3 but less than 4 years
   5. 4 years or more

6. What is your highest level of education?
   1. high school graduate
   2. some college
   3. Associate's degree
   4. Bachelor's degree
   5. Master's degree
   6. Doctoral degree

7. Do you use a computer on the job?
   1. yes
   2. no

If you answered yes to question 7, please answer questions 8 - 11. If you answered no, please skip to question 12.

8. What type of computer do you use most often on the job?
   1. Zenith Z-248 or other IBM compatible
   2. Apple Macintosh
   3. other

9. How long have you used the computer specified in question 8?
   1. less than 3 months
   2. at least 3 months but less than 1 year
   3. 1 year or more

10. Approximately how many hours per week do you use your computer on the job?
    1. less than 3
    2. at least 3 but less than 5
    3. at least 5 but less than 10
    4. at least 10 but less than 20
    5. 20 or more

11. How many different software packages do you use on the job?
    1. 1
    2. 2 - 3
    3. 4 - 6
    4. over 6

12. Do you own a computer at home?
    1. yes
    2. no

If you answered yes to question 12, please answer questions 13 - 16. If you answered no, please skip to question 17.

13. What type of computer do you use at your home?
    1. Zenith Z-248 or other IBM compatible
    2. Apple Macintosh
    3. other

14. How long have you used the computer specified in question 13?
    1. less than 3 months
    2. at least 3 months but less than 1 year
    3. 1 year or more

15. Approximately how many hours per week do you use your computer at home?
    1. less than 3
    2. at least 3 but less than 5
    3. at least 5 but less than 10
    4. at least 10 but less than 20
    5. 20 or more

16. How many different software packages do you use at home?
    1. 1
    2. 2 - 3
    3. 4 - 6
    4. over 6

All respondents should resume answering with question 17.

17. On a scale of 1 to 5, with 1 being the least advanced and 5 being the most advanced, how would you rate your computer skills?
    1. 1
    2. 2
    3. 3
    4. 4
    5. 5

Section 2: The following questions all pertain to the computer you use on the job (i.e. your answer to question 8). If you do not use a computer on the job, please return your questionnaire at this time. If you do use a computer on the job, please answer on the answer sheet provided. Please note that "actual working time" refers to the amount of time spent learning a particular program or skill.

Example: day 1: 2 hours
day 2: 3 hours
Actual working time = 5 hours

18. Do you know how to copy files (applications or documents)?
    1. yes
    2. no

19. Do you know how to delete files (applications or documents)?
    1. yes
    2. no

20. Do you know how to create subdirectories (folders)?
    1. yes
    2. no

21. Do you know how to rename a file (document)?
    1. yes
    2. no

22. Do you know how to open a particular file (document)?
    1. yes
    2. no

23. Do you know how to list/view all files (documents) within a subdirectory (folder)?
    1. yes
    2. no

24. Do you know how to move a file (document) from one subdirectory (folder) to another?
    1. yes
    2. no

25. Do you know how to format (initialize) a disk?
    1. yes
    2. no

26. Do you know how to copy (duplicate) a disk?
    1. yes
    2. no

27. How much actual working time did it take you to learn <u>all</u> operations listed in questions 18 - 26?
    1. less than 1 hour
    2. at least 1 but less than 3 hours
    3. at least 3 but less than 5 hours
    4. at least 5 but less than 7 hours
    5. at least 7 but less than 9 hours
    6. 9 hours or more
    7. have not yet learned all operations in questions 18 - 26

Section 3: The following questions ask about specific types of applications you may use on the job. Please answer on the answer sheet provided. Again, please note that "actual working time" refers to the amount of time actually spent learning the program.

Example: day 1: 2 hours
day 2: 3 hours
Actual working time = 5 hours

28. Do you use word processing software on the job?
    1. yes
    2. no

29. How much actual working time did it take you to learn your primary word processing program?
    1. less than 4 hours
    2. at least 4 but less than 8 hours
    3. at least 8 but less than 12 hours
    4. at least 12 but less than 16 hours
    5. at least 16 but less than 20 hours
    6. at least 20 but less than 24 hours
    7. 24 hours or more
    8. do not use my computer for word processing

30. Do you use a spreadsheet program on the job?
    1. yes
    2. no

31. How much actual working time did it take you to learn your primary spreadsheet program?
    1. less than 4 hours
    2. at least 4 but less than 8 hours
    3. at least 8 but less than 12 hours
    4. at least 12 but less than 16 hours
    5. at least 16 but less than 20 hours
    6. at least 20 but less than 24 hours
    7. 24 hours or more
    8. do not use a spreadsheet on my computer

32. Do you use a database program on the job?
    1. yes
    2. no

33. How much actual working time did it take you to learn the database program you are using?
    1. less than 5 hours
    2. at least 5 but less than 10 hours
    3. at least 10 but less than 15 hours
    4. at least 15 but less than 20 hours
    5. at least 20 but less than 25 hours
    6. at least 25 but less than 30 hours
    7. 30 hours or more
    8. do not use a database program on my computer

34. Do you use a graphics/presentation program on the job?
    1. yes
    2. no

35. How much actual working time did it take you to learn your graphics/ presentation program?
    1. less than 4 hours
    2. at least 4 but less than 8 hours
    3. at least 8 but less than 12 hours
    4. at least 12 but less than 16 hours
    5. at least 16 but less than 20 hours
    6. at least 20 but less than 24 hours
    7. 24 hours or more
    8. do not use a graphics/presentation program on my computer

36. Do you use computer-aided design/computer-aided manufacturing (CAD/CAM) software on the job?
    1. yes
    2. no

37. How much actual working time did it take you to learn the CAD/CAM program you are using?
    1. less than 5 hours
    2. at least 5 but less than 10 hours
    3. at least 10 but less than 15 hours
    4. at least 15 but less than 20 hours
    5. at least 20 but less than 25 hours
    6. at least 25 but less than 30 hours
    7. 30 hours or more
    8. do not use a CAD/CAM program on my computer

38. On the average, how much actual working time does it take you to learn a new application program?
    1. less than 4 hours
    2. at least 4 but less than 8 hours
    3. at least 8 but less than 12 hours
    4. at least 12 but less than 16 hours
    5. at least 16 but less than 20 hours
    6. at least 20 but less than 24 hours
    7. 24 hours or more

39. How many software application packages do you feel proficient with?
   1. 1
   2. 2
   3. 3
   4. 4 - 5
   5. 6 - 7
   6. 7 - 8
   7. more than 8

Section 4: The following section asks you to rate the user-friendliness of various aspects of the computer system you use on the job (i.e. your answer to question 8). In rating these attributes, please use the following scale in answering the questions on the answer sheet provided:

1	2	3	4	5	6	7
extremely difficult	difficult	moderately difficult	moderate	moderately easy	easy	extremely easy

If you use a Zenith or other IBM compatible most often on the job, please answer questions 40 - 47. If you use a Macintosh, please skip to question 48, making sure to leave answers 40 - 47 blank on your answer sheet. If you do not use any of the computers listed above, please stop here and return your questionnaire and answer sheet at this time. All users will resume answering questions at question number 56.

40. On the average, how difficult/easy is using the commands within the software packages you use on the job?

41. How difficult/easy is using the keyboard, as compared with other input devices you have seen or used for entering appropriate commands?

42. How difficult/easy is working with the function keys (F1 - F10) for specific operations?

1	2	3	4	5	6	7
extremely difficult	difficult	moderately difficult	moderate	moderately easy	easy	extremely easy

43. How difficult/easy is recalling the meanings of all the function keys between different application programs?

44. How difficult/easy is learning the meanings of function keys for each application program?

45. How difficult/easy is moving the cursor to different points around the screen?

46. On the average, how difficult/easy is performing the basic file operations named in questions 18 - 26?

47. Overall, how difficult/easy is using your computer?

If you use a <u>Zenith or other IBM compatible</u>, please skip to question 56 making sure to leave questions 48 - 55 blank on your answer sheet. If you use a <u>Macintosh</u>, please answer questions 48 - 55 using the scale below:

1	2	3	4	5	6	7
extremely difficult	difficult	moderately difficult	moderate	moderately easy	easy	extremely easy

48. How difficult/easy is working with the icons on the Macintosh in the software packages you use on the job?

49. How difficult/easy is understanding what each icon represents?

50. How difficult/easy is working with the Macintosh windows?

51. How difficult/easy is using the mouse for selecting specific commands?

1	2	3	4	5	6	7
extremely difficult	difficult	moderately difficult	moderate	moderately easy	easy	extremely easy

52. How difficult/easy is learning to use the mouse?

53. How difficult/easy is moving the cursor to different points around the screen?

54. How difficult/easy is performing the basic file operations named in questions 18 - 26?

55. Overall, how difficult/easy is using your computer?

Section 5: All users should complete this section. The following statements solicit your attitudes about using your computer on the job. Please use the following scale to respond to the statements in numbers 56 - 64:

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

56. My computer helps me perform in my job.

57. Using my computer increases my productivity.

58. Using my computer has increased my chances of getting a better job.

59. Using my computer has increased my chances for promotion.

60. Using my computer has benefitted my organization.

61. My computer has helped me do my job better.

62. I am extremely satisfied with the computer I use on the job.

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

63. I would prefer to use a keyboard-driven, text-based interface such as MS-DOS.

64. I would prefer to use a mouse-driven, graphical interface such as that used by the Macintosh.

Section 6: Please answer the following questions on the answer sheet provided. You may wish to double check your answer sheet to insure that you begin with question number 65.

65. Do you supervise other personnel?
    1. yes
    2. no

66. Are you responsible for output generated by a computer?
    1. yes
    2. no

If you answered yes to <u>either</u> question 65 or 66, please answer questions 67 - 69 using the scale below:

1	2	3	4	5	6	7
very poor	poor	below average	average	above average	good	very good

67. How would you describe the quality of text produced by your computer system?

68. How would you describe the quality of graphics produced by your computer system?

69. How would you describe the overall appearance of documents produced by your computer system?

Section 7: Please answer all of the following questions which apply to software you currently use on the job. Please answer these questions directly on this questionnaire.

70. What word processing program do you use?

71. What spreadsheet program do you use?

72. What database program do you use?

73. What graphics/presentation program do you use?

74. What CAD/CAM package do you use?

Thank you for completing this questionnaire. Please return your answer sheet and questionnaire in the envelope provided. If you have lost the return envelope, please return the materials to the following address through the base distribution system:

Capt Michael G. Morris
AFIT/LSG
Wright-Patterson AFB, OH 45433

Again, thank you for your help.

Bibliography

1. Adcock, Jerry K. Design of a Graphics User Interface for a Database Management System . MS Thesis, Naval Postgraduate School, Monterrey CA, 20 June 1987 (AD-A171393).

2. Bennett, Kevin. Design of Graphic Displays in Computerized Systems, Quarterly Report, 1 September 1984 - 30 November 1984. Contract N00014-83-D-0689. The Office of Naval Technology, January 1985 (AD-A150071).

3. Butler, Keith A. "Connecting Theory and Practice: A Case Study of Achieving Usability Goals," CHI '85 Proceedings. 85-89. New York: Association for Computing Machinery, 1985.

4. Card, Stuart K. and others. "The Keystroke-Level Model of User Performance Time with Interactive Systems," Communications of the ACM 23: 396-409 (July 1980).

5. Carey, Tom. "User Differences in Interface Design," Computer 15: 14-20 (November 1982).

6. Davis, Gordon B. and Olson, Margrethe H. Management Information Systems: Conceptual Foundations, Structure, and Development (Second Edition). New York: McGraw-Hill Book Company, 1985.

7. Dwyer, Daniel J. An Exploratory Study of the Effect of Screen Size and Resolution on the Legibility of Graphics in Automated Job Performance Aids, October 1981 - December 1983. Orlando FL: Naval Training Equipment Center, 30 May 1985 (AD-A155989).

8. Embley, David W. and Nagy, George. "Behavioral Aspects of Text Editors," ACM Computing Surveys 13: 33-70 (March 1981).

9. Gittins, David. "Icon-based Human-Computer Interaction," International Journal of Man-Machine Studies 24: 519-543 (June 1986).

10. Grudin, Jonathan. "The Case Against User Interface Consistency," Communications of the ACM 32: 1164-1173 (October 1989).

11. Guastello, Stephen J. and others. "Verbal Versus Pictorial Representations of Objects in a Human-Computer Interface," International Journal of Man-Machine Studies 31: 99-120 (July 1989).

12. Herot, Christopher F. "Graphical User Interfaces," Proceedings of the NYU Symposium on User Interfaces. 83-104. Norwood NJ: Ablex Publishing Corporation, 1984.

13. Hollan, James D. and others. Graphical Interfaces for Simulation. April 1986. La Jolla CA: Institute for Cognitive Science, University of California, May 1986 (AD-A171826).

14. Ives, Blake. "Graphical User Interfaces for Business Information Systems," MIS Quarterly Special Issue: 15-47 (December 1982).

15. ----- and others. "The Measurement of User Information Satisfaction," Communications of the ACM, 25: 785-793 (October 1983).

17. Johnson. Jeff. "How Faithfully Should the Electronic Office Simulate the Real One?," SIGCHI Bulletin 19: 21-25 (October 1987).

18. Karat, John and others. "A Comparison of Menu Selection Techniques: Touch Panel, Mouse, and Keyboard," International Journal of Man-Machine Studies 25: 73-88 (July 1986).

19. Lund, Michelle A. "Evaluating the User Interface: The Candid Camera Approach," CHI '85 Proceedings. 107-113. New York: Association for Computing Machinery, 1985.

20. Macintosh or MS-DOS?, 11 November 1987-15 January 1988. Diagnostic Research, Inc., San Francisco CA, January 1989.

21. Moran, Thomas P. "An Applied Psychology of the User," ACM Computing Surveys 13: 1-11 (March 1981).

22. Nelson, R. Ryan and Paul H. Cheney. "Training End Users: An Exploratory Study," MIS Quarterly 11: 547-559 (December 1987).

23. Norman, Donald A. "Design Rules Based on Analyses of Human Error," Communications of the ACM 26: 254-258 (April 1984).

24. Rogers, Yvonne. "Pictorial Representations of Abstract Concepts Relating to Human-Computer Interaction," SIGCHI Bulletin 18: 43-44 (October 1986).

25. Schneiderman, Ben. "Direct Manipulation: A Step Beyond Programming Languages," Computer 16: 57-69 (August 1983).

26. ——-. "The Future of Interactive Systems and the Emergence of Direct Manipulation," Proceedings of the NYU Symposium on User Interfaces. 1-27. Norwood NJ: Ablex Publishing Corporation, 1984.

27. Thomas, John C. "Organizing for Human Factors," Proceedings of the NYU Symposium on User Interfaces. 29-46. Norwood NJ: Ablex Publishing Corporation, 1984.

28. Whiteside, John and others. "User Performance with Command, Menu, and Iconic Interfaces," CHI '85 Proceedings. 185-191. New York: Association for Computing Machinery, 1985.

29. Wixon, Dennis and John Whiteside. "Engineering for Usability: Lessons from the User Derived Interface," CHI '85 Proceedings. 144-147. New York: Association for Computing Machinery, 1985.

Vita

Captain Michael G. Morris [redacted] Upon graduation from Shelby Senior High School in Shelby, Ohio in 1981, he accepted a four-year AFROTC scholarship to Bowling Green State University in Bowling Green, Ohio. While at Bowling Green, Captain Morris majored in Secondary Social Studies Education graduating Magna Cum Laude in December 1985. In May 1986, he was assigned to the 3271st School Squadron at Lackland AFB as the unit's Executive Officer where he was in charge of administrative support for students attending the Basic Cryptographic Maintenance course. In July of 1987, Captain Morris assumed similar duties for the 3294th Student Squadron for students attending the Basic Security Specialist course. In October 1988, Captain Morris was chosen as the Executive Officer for the 3700th Air Base Group where he was in charge of administrative and executive support for the Base Commander. In May 1989, Captain Morris entered the Information Resource Management Program in the School of Systems and Logistics, Air Force Institute of Technology. Captain Morris is married to the former Linda McCoy of Marysville, Ohio.

[redacted]

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
December 1990

3. REPORT TYPE AND DATES COVERED
Master's Thesis

4. TITLE AND SUBTITLE
A Comparison of Human-Computer Interfaces in Air Force Organizations

5. FUNDING NUMBERS

6. AUTHOR(S)
Michael G. Morris, Captain, USAF

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Air Force Institute of Technology, WPAFB OH 45433-6583

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT/GIR/LSM/90D-7

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)* This study investigated differences in organizational efficiency and effectiveness for users of graphical user interfaces and text-based interfaces on personal computers in Air Force offices. Areas of interest included amount of time required to learn the basic system, amount of time required to learn new applications, users' ratings of user-friendliness, users' perceptions of the extent that their system helps them perform in their job, the number of software packages used on the job by users of each system, user satisfaction, responsible authorities' ratings of quality of output, and the relationship between user job experience level and interface used on the job. Two populations across two organizations were identified for survey administration--users of graphical user interfaces and users of text-based interfaces. The results of the study indicated that for the organizations surveyed, graphical user interfaces offer significant advantages in each of the areas investigated. Finally, the results of the study revealed that less experienced users tend to use graphical interfaces over text-based interfaces. In addition, military members used graphics-based systems in greater numbers while civilian users were more likely to use text-based systems.

14. SUBJECT TERMS
Man Computer Interface, Display Systems Graphics, Microcomputers, User Needs, Graphical User Interfaces

15. NUMBER OF PAGES
139

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL